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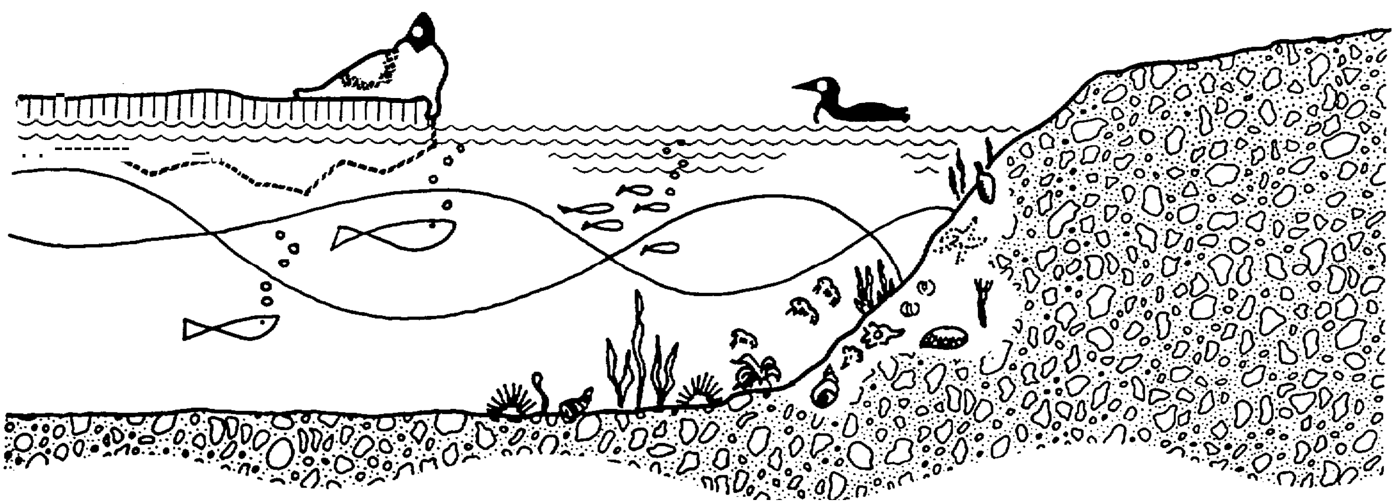
MACROBENTHOS



Baffin Island Oil Spill Project

WORKING REPORT SERIES

1980 STUDY RESULTS

BIOS Working Report Series

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Correct citation for this publication:

Cross, W.E., and Thompson, D.H., 1981, Macrobenthos - 1980 Study Results. (BIOS) Baffin Island Oil Spill Working Report 80-3: 81 p.

EFFECTS OF OIL AND DISPERSED OIL ON NEARSHORE MACROBENTHOS AT CAPE HATT, NORTHERN BAFFIN ISLAND.

I. RESULTS OF 1980 PRE-SPILL STUDIES

by

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Edmonton, Alberta

March 1981

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ACKNOWLEDGEMENTS

Assistance was provided by many people without whose efforts and expertise this study would not have been possible. Special thanks are due to fellow divers John Barrie, Michael Fabijan and Tommy Jackoosie who collected most of the samples, and to John Barrie, Warren Dunlop, Ann Maltby, Carole Martin and Patricia Mohr, who carried out most of the laboratory analysis. Identification of macroalgae, performed by Bob Wilce of the University of Massachusetts, and species verifications provided by Diana Laubitz (crustaceans), Judy Fournier (polychaetes), Peter Frank (sipunculids) and Muriel Smith (gastropod) of the National Museum of Canada, and by E.G. Atkinson (bivalves) of the Arctic Biological Station, are gratefully acknowledged. The assistance of LGL staff Kris Black (drafting), Chris Holdsworth (computer analyses), Bev Griffen and Helen Hogarth (report preparation) and especially John Richardson (who assisted in study design, data interpretation and scientific editing) is gratefully acknowledged.

This study is a part of the Baffin Bay Island Oil Spill (BIOS) project, an internationally funded study administered by the Environmental Protection Service of the federal Department of Environment. Funding has been provided by the governments of Norway, the United States of America (NOAA/OCSEAP and Us. Coast Guard), and Canada (Department of Indian Affairs and Northern Development, Dept. of Fisheries and Oceans, Dept. of Environment, and the Canadian Coast Guard), and by the Canadian oil industry. Thanks are extended to Rolph Davis of LGL Ltd., to Peter Blackall and Gary Sergy of the BIOS project office (EPS), and to Richard Clark, Howard Hume, Norm Snow and Bill Werner of Petro-Canada for administrative and logistical support throughout the study. The advice and encouragement of Biological Technical Committee members Ron Foreman, Roger Green, Gary Sergy, Norm Snow and John Vandermeulen are gratefully acknowledged.

INTRODUCTION

The pace of exploration and development of hydrocarbon resources in arctic and subarctic marine areas is likely to increase in the future. Already, exploratory drilling is occurring in the Canadian Beaufort Sea, Sverdrup Basin, Davis Strait and the Labrador Sea, and plans call for offshore drilling in the Alaskan Beaufort Sea, Lancaster Sound and Baffin Bay in the near future. Plans for major offshore oil production are being developed for the Canadian Beaufort Sea by industry, and the Federal Environmental Assessment Review Office is preparing to evaluate the plans. Year-round transport of oil through the Northwest Passage, Baffin Bay and Davis Strait is now a distinct possibility.

Clearly, as the amount of activity increases, the possibility of an accidental release of oil also increases. If oil is released there will be substantial pressure to use chemical dispersants to try to keep the oil from accumulating on the surface of the water or on shorelines where extremely small amounts can have dramatic effects on birds.

With or without the use of chemical dispersants, released oil will enter the water column and, especially in nearshore locations, impinge upon the bottom. The initial biological effects will occur among planktonic and benthic invertebrates, although effects at higher levels of the food web may result from the mortality of or accumulation of oil in important food species. The use of chemical dispersants may increase biological effects because of dispersant toxicity, increased dissolution of toxic oil fractions, or increased opportunity for the accumulation of oil in sediments. Also, the primary use of dispersants will likely be as a countermeasure to prevent the impingement of oil on shorelines ; hence they will be used primarily in shallow, productive nearshore waters, many of which are important feeding areas for birds and marine mammals.

Recently, considerable attention has been given to the effects of oil and dispersants on individual species of arctic marine flora and fauna under experimental conditions (Percy and Mullin 1975, 1977; Percy 1976, 1977, 1978; Busdosh and Atlas 1977; Malins 1977; Atlas et al. 1978; Foy 1978, 1979; Hsiao et al. 1978), but to date the potential effects on whole communities are unknown. During the recent TSESIS oil spill investigations, a comparison of approaches towards detecting biological effects supported the 'ecosystem approach' advocated by Mann and Clark (1978): data on reproductive abnormalities in a sensitive species only confirmed effects that were already obvious at the community level (Elmgren et al. 1980). In temperate waters community studies have been carried out for up to 10 years after a spill (e.g. Sanders et al. 1980), but most of these studies have been after the fact; hence they lack adequate 'control' data on pre-spill conditions, on naturally occurring changes that would have occurred in the absence of the spill, or on both (National Academy of Sciences 1975; cf. Bowman 1978). Another shortcoming of many spill studies has been the lack of supporting data on oceanographic and atmospheric conditions , and on hydrocarbon concentrations in the impacted environment (National Academy of Sciences 1975) .

To date, no major oil spill has occurred in Canadian arctic waters. In 1978–1979 the Arctic Marine Oilspill Program (AMOP) examined the need for research associated with experimental oilspills in cold Canadian waters, and thereafter instigated the Baffin Island Oilspill (BIOS) project to study a controlled introduction of oil and dispersed oil onto shorelines and into nearshore arctic waters. The objectives of this project were to assess the environmental impact of chemical dispersants and the relative effectiveness and impact of other shoreline protection and clean-up techniques. The BIOS project is an internationally funded, multidisciplinary study being carried out by engineers, meteorologists , physical oceanographers, geologists, chemists and biologists from various government departments, industry and research organizations. The nearshore component of the BIOS project includes studies of microbiology and benthic microbiology, atmospheric and oceanographic conditions, and chemical properties of the water column and surface sediments, with special emphasis on concentrations of petroleum hydrocarbons.

The objectives of the microbiological component of the BIOS project are to assess the effects of oil and dispersed oil on the macrophytic algae, the relatively immobile benthic infauna (e.g. bivalves, polychaetes) and the motile epibenthos (e.g. amphipods, urchins) in shallow arctic waters. Variables to be examined include total abundance/biomass and community structure, as well as the abundance, biomass, population age structure and length-weight relationships of dominant species in these communities. The statistical design of the study is ‘optimal’ for impact assessment (in the sense of Green 1979) in that it includes both temporal (pre-spill) and spatial (unoiled bay) controls. The present report provides baseline data from the first of two pre-spill sampling periods (September 1980, August 1981). These data, together with post-spill data from an uncontaminated (control) bay, will be used as a basis of comparison with post-spill data from the experimental bays.

METHODS

Field Collection Procedures

Field work was carried out during 7-13 August and 29 August-17 September 1980 from the BIOS project camp located at Cape Hatt, Baffin Island (Fig. 1). All sampling was carried out by divers working from inflatable boats (Zodiacs) moored in Bay 11 (August) or Bay 12 (September). Processing and preservation of samples were performed in tents erected on the beach at the same locations (Fig. 1). During the preliminary survey in early August, Bays 9, 10, 11 and 13 were examined with the primary objective of selecting three suitable bays and three suitable transects within each bay; the aim was to select sites with similar substrates and faunal assemblages. During September, systematic sampling was carried out in Bays 9, 10, and 11, and additional collections were made in Z lagoon to provide specimens for tissue analysis (Fig. 1). The following sections apply to the systematic work in September.

Sampling Locations

Three contiguous 50 m transects were set parallel to the shoreline at each of two depths in each of Bays 9, 10 and 11 (Fig. 2). A depth of 7 m was selected as the primary sampling depth, and transect locations at that depth were chosen in each bay using as criteria (1) similarity in substrate characteristics and infaunal community composition among transects and bays (as determined during the preliminary survey), and (2) facility of sampling (soft substrate with as little surface rock as possible). The second

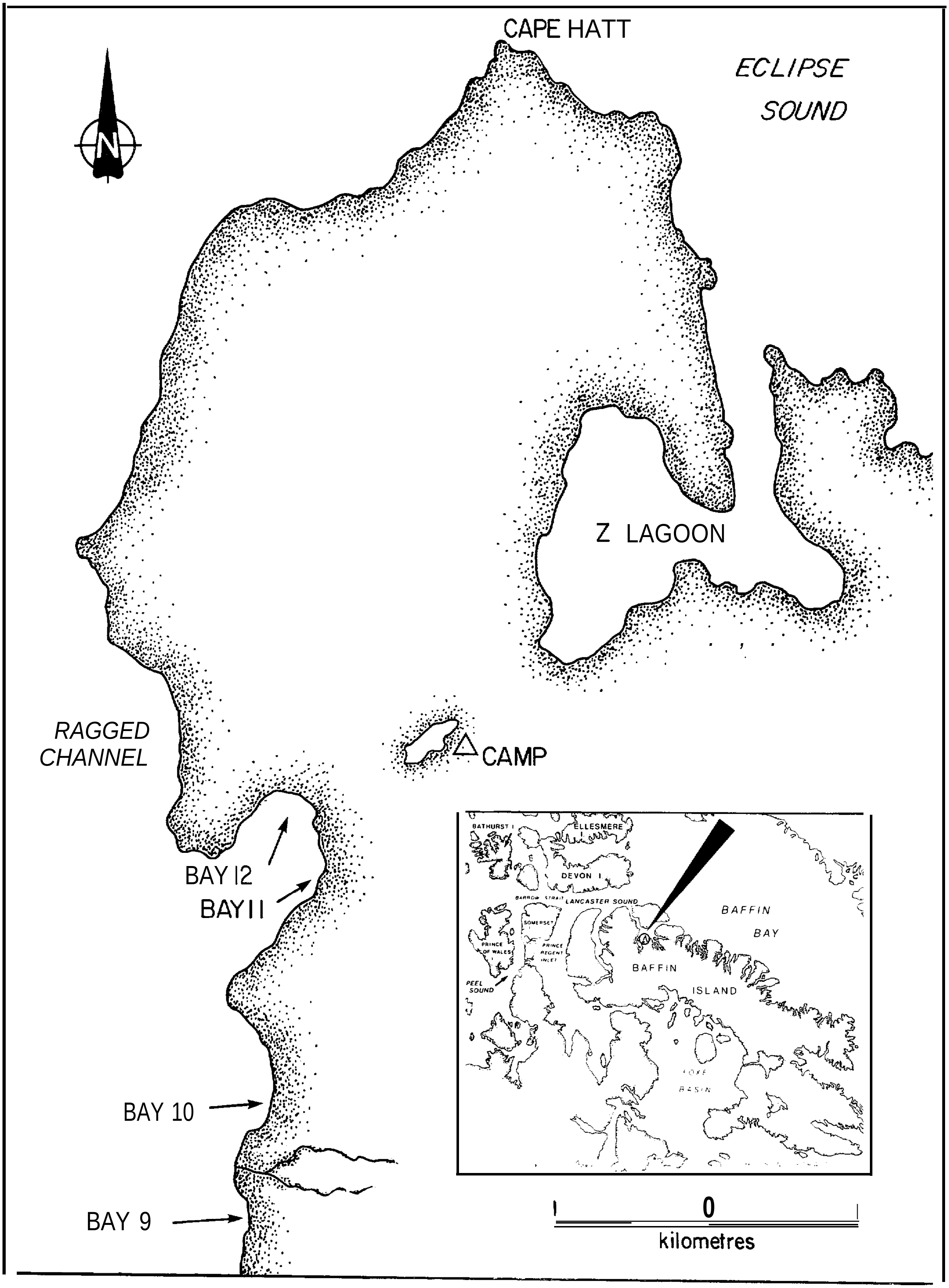

FIG. 1. Locations of study bays at Cape Hatt, northern Baffin Island.

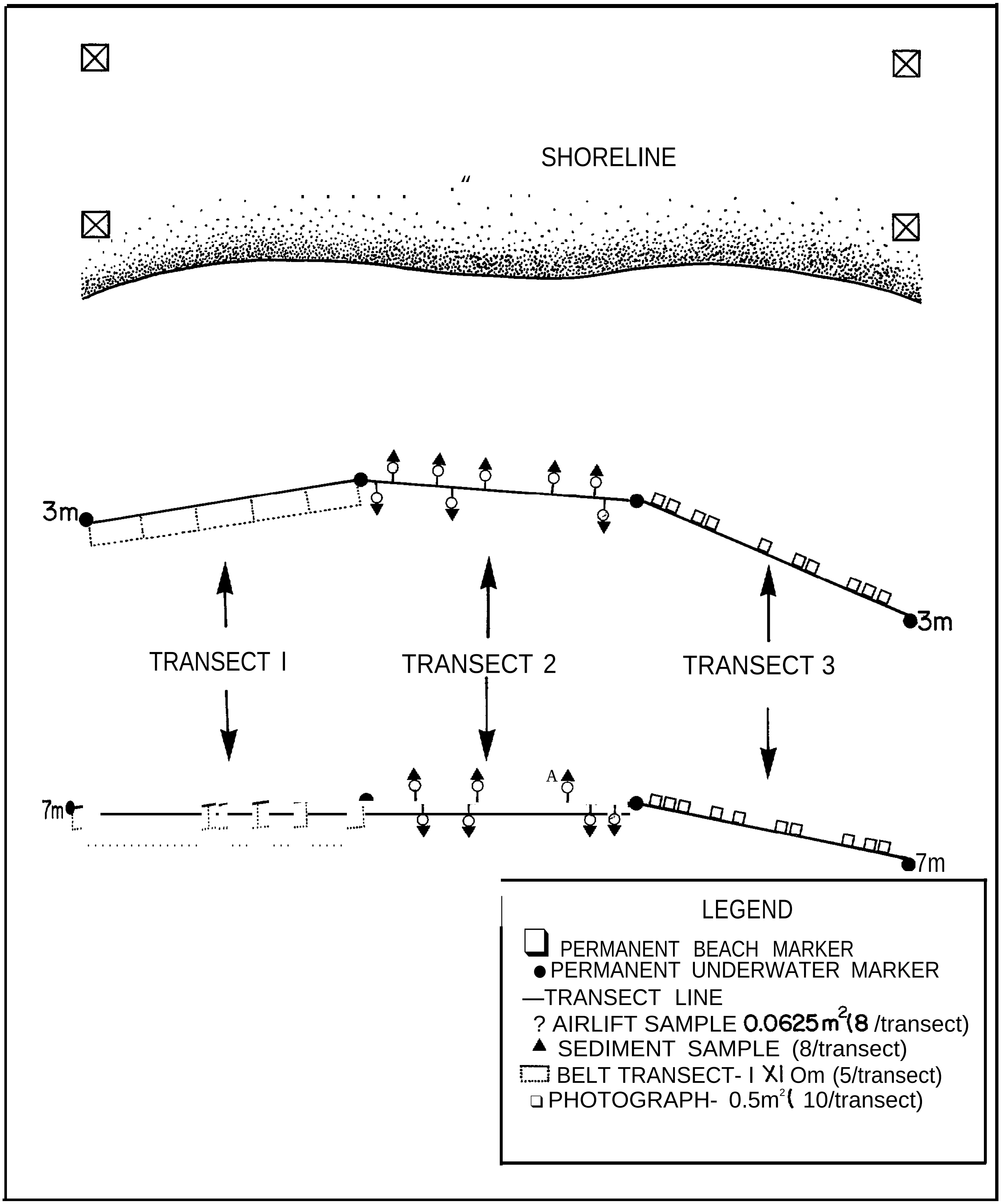

FIG. 2. Schematic representation of sampling design for BIOS benthic study. Each of the four sample types shown in the legend was collected on each of three transects at each of two depths in each of three bays. For clarity, only one or two sample types are shown per transect in this figure.

transect in each bay was located immediately inshore of the 7 m transect at a depth of 3 m, where a relatively even cover of algae occurred in each bay.

Transect locations at 3 and 7 m depths were marked by driving steel rods approximately L m into the substrate at 50 m intervals along a 150 m line. In each bay, sighting lines toward the ends of the lines of transects were established on the shore by placing pairs of markers on the beach.

A 150 m transect rope marked at 1 m intervals was set between the permanent stakes before (and removed after) sampling at each bay/depth combination. Numbered plastic tags attached to the line indicated randomly selected 1 m^2 airlift sampling locations immediately seaward or shoreward of the line; the exact location of the sample within each of these 1 m^2 areas was that with the least amount of surface rock. Photograph locations along each transect were also randomly selected, and were indicated on a list attached to the camera. Sample locations for airlifts and photographs were re-randomized for each transect. In situ counts and supporting collections were made within 1 x 10 m belts along each transect line.

Airlift Sampling

Infauna were sampled by means of a self-contained diver-operated airlift. Eight replicate samples were obtained on each of 3 transects at each of 2 depths in each of 3 bays (total of 144 samples).

The airlift consisted of a weighted 2 m length of pipe 8 cm in diameter fitted at the top with a 1 mm mesh net which retained the sample and could be removed quickly and capped. Air was supplied from a 3000 psi (20 MPa) air cylinder fitted with the first stage of a diving regulator which reduced air pressure to approximately 125 psi (860 kPa) above ambient. Areas to be sampled were demarcated by a ring containing an area of 0.0625 m^2.

The ring was placed on the bottom and pushed'as far as possible into the substrate to contain shallow infauna. The airlift was inserted into the ring, the air was turned on, and the mouth of the airlift was moved around to thoroughly cover the area within the ring. The air was turned off when all visible organisms had been collected, and the net on the airlift was then removed, capped and replaced. The depth of penetration of the airlift into the substrate (range 2-25 cm; mean ± SD = 13.2 ± 4.4) was then measured to the nearest cm, and a sample of surface sediment was taken immediately beside the excavated area. Large rocks remaining within the ring were removed and either weighed underwater using a plastic bucket and a brass fish scale and then discarded, or placed in a numbered sample bag cross-referenced with the airlift sample. After 3 or 4 samples had been taken they were raised to the boat and rinsed in the collecting bags from the side of the boat in order to remove fine sediments. Immediately after each dive all samples were returned to the field laboratory.

Quantitative Photography

A photographic record of each transect was obtained on colour slide film using a Nikonos camera with a 15 mm lens, paired Vivitar electronic flashes and a fixed focus framer covering a bottom area of approximately 0.5 m^2. Ten photographs were taken at randomly located intervals along each transect line. In addition to providing a permanent visual record of each study area, photographs were used to estimate densities of visible surface fauna that were too sparsely distributed to be represented adequately in airlift samples.

In Sit-u Counts

Macrophytes and those invertebrates too large and sparsely distributed to be represent.atively sampled by airlift or camera were counted in situ. On each transect, counts of urchins, starfish and individual kelp plants, as well as estimates of percent bottom cover by algae, were made within five 1 x 10 m strips parallel to and immediately adjacent to the transect line. Collections of representative plants and animals were also made for species identification.

Laboratory Analvsis Procedures

All samples were processed in the field within 12 h of collection. Samples were emptied into large plastic trays, and nets were carefully rinsed and picked clean. Large conspicuous animals and algae were separated from the sample, labeled and preserved in 10% formalin in separate jars. Large rocks and gravel were picked from the sample and weighed on an Ohaus triple-beam balance. The balance of the sample was labeled and preserved in 10% formalin. Macrophytic algae from systematic transect collections were pressed on herbarium paper and dried at room temperature.

Detailed laboratory processing and analysis of samples was carried out within 1 to 3.5 months of collection. Samples were initially rinsed to remove formalin and sediment, and then separated into 5 fractions. Al 1 material passing through a 1 mm mesh screen and retained on a 0.45 mm mesh screen was preserved in alcohol for future reference. A 'floating' fraction, separated by rinsing, contained algae, detritus and most soft bodied animals. This fraction was examined under a binocular microscope and animals $\geq$1 mm in length were sorted into major taxonomic groups; the remaining algae and detritus was blotted dry and weighed on a Mettler PT 200 balance. In 7 of the 144 samples (when large volumes of algae were present), large and conspicuous organisms were picked from the entire sample but only a subsample of known weight was examined microscopically. Different size fractions (l-2.8 mm; 2.8-5.6 mm; $\geq$5.6 mm) of the balance of the sample, separated in nested seives, contained sand, gravel, bivalves and some soft bodied animals. Each fraction was sorted separately in glass trays into major taxonomic groups. Shell fragments from the largest size fraction and entire bivalve shells from each fraction were separated, labeled and stored for future reference. Gravel from the largest size fraction was blotted dry and weighed.

All animals were identified to species level whenever possible; unidentified or tentatively identified species were sent to appropriate authorities for identification or verification (see Acknowledgements). For each taxon identified, individuals were counted, gently blotted dry and weighed together to the nearest milligram on a Mettler PT 200 balance. Unless otherwise specified (see below), all weights presented in this report are preserved (10% formalin) wet weights, including mollusc shells but excluding polychaete tubes. Lengths of individuals of all bivalve species, and diameters of the calcareous oral rings of the holothurian *Myriotrochus rinkii*, were measured to the nearest millimetre. After laboratory examination, all taxa were stored in 75% alcohol; a solution of 3% propylene glycol in 75% alcohol was used for crustaceans.

For each of three common bivalve species (*Mya truncata*, *Astarte borealis* and *Macoma calcarea*), the relationships between length, wet weight and dry weight were derived as follows: For each bay, approximately fifty undamaged individuals of each species were selected from airlift samples taken along the middle transect at 7 m depth. If necessary to obtain a sample size of 50 per bay, animals from the inner ends of the outer two transects were also used. For each individual the length, wet weight including shell, wet meat weight, and dry (constant) meat weight were determined. Constant dry weight was obtained by drying at 60″c in a Fisher Isotemp Oven Model 301 and weighing at daily intervals until constant weight was found.

Species identifications of macrophytic algae were carried out on all herbarium specimens. Dominant macrophytes in one randomly selected airlift sample from the 3 m depth in each bay were identified, and a species list was made for subsamples of two of these airlift samples.

Data Processing and Analysis

All data collected in the field and all results from laboratory analyses were coded for computer processing. Computer programs deveLoped by LGL were used to generate the sample by sample, transect by transect, and bay by bay tabulations that were used to select species and taxa for further analyses. Other LGL programs were used to organize the data into a format acceptable to packaged statistical programs. Prior to analyses a logarithmic transformation (log [x+1]) was applied to density and biomass data in order to reduce the skewness inherent in such data.

Two-factor (depths and bays) fixed-effects analyses of variance with transects nested within depths and bays were used to examine and test the variability in the benthic community. Many of these analyses showed significant bay by depth interactions, so separate single factor (bays) analyses were run on data from each depth; again, transects were nested within bay. Analyses of variance were performed by the SAS computer programs (Helwig and Council 1979).

Factor analysis with varimax rotation (BMDP4M, Dixon and Brown 1977) was used to identify recurring groups of species. Factor scores generated by this analysis were used as dependent variables in a multivariate analysis of variance (SAS general linear models program, Helwig and Council 1979) that was used to test for differences in community composition among bays and between depths.

The appropriate transformation used to determine length-weight relationships of dominant bivalve species was selected after analysis of (1) scatter plots of the original data, and (2) plots of residuals generated by regression analyses. Analyses of covariance with length as the covariate were used to test for differences in dry meat weight among bays. All of these analyses utilized the BMDP computer programs (Dixon and Brown 1977).

The mean lengths of selected bivalve species were calculated for each sample and analyses of variance were used to test whether mean lengths of these species differed among bays or between depths.

Because of the large number of analyses carried out in this study and the even larger number that will be employed throughout the project, some type I errors in statistical inference would be expected if the conventional α = 0.05 criterion of statistical significance were applied. Hence, a criterion of α = 0.01 was used to distinguish significant ($P \leq 0.01$) from non-significant ($P > 0.01$) results in all univariate analyses. The multivariate analysis of variance is an extremely powerful test and hence we used an α = 0.05 criterion in this analysis.

SITE DESCRIPTIONS

The study area for the nearshore component of the 1980 Baffin Island Oil Spill Project consisted of three shallow embayments in Ragged Channel, some 5-8 km SSE of Cape Hatt, Eclipse Sound (72°27'N, 79°51'W). Bays 9 and 10 are shallow indentations in the coastline, each about 500 m in length, separated by the delta of a small stream and a distance of somewhat less than 500 m. Bay 11 has been designated as the lower half (and Bay 12 as the upper half) of a deeper embayment some 1 km x 1 km in dimensions, located approximately 1 km north of Bay 10 (Fig. 1).

Information on the nearshore geology of the study area may be found in Barrie et al. (1981); the following data on grain size distribution are abstracted from that work. Sediments in the nearshore areas of the study bays were generally coarse to fine sand at the shallowest depths, and increasingly fine with increasing depth (Fig. 3). Sediments at the 3 m sampling depth were fine sand in all 3 bays. At the 7 m depth sediments were very fine sand in Bays 9 and 10 and coarse silt in Bay 11 (Table 1). On a volumetric basis, rock formed between 13.6 and 18.9% of the volume sampled by the airlift sampler at the 3 m depth, and from 7.2 to 16.8% at the 7 m depth. At both depths, airlift samples from Bay 11 contained the smallest amount of rock.

The three study bays (9, 10 and 11) were generally similar in substrate and in floral and faunal characteristics. The beaches and intertidal zones were composed of a gravel/cobble pavement overlying sand with scattered rocks and boulders. At depths of 1–2 m a relatively flat, predominantly sand bottom occurred, and the rockweed Fucus sp., together with a relatively sparse cover of smaller algae and patches of tunicates (including Rhizomolgula globularis) were the only conspicuous biota. In bays 9 and 10 a steep, rocky slope with a relatively dense cover of Fucus sp. occurred between 2 and 3 m depths. At the bottom of this slope, and at an equivalent depth in Bay 11, a zone with a relatively even and nearly complete cover of algae stretched seaward for distances from 1 to 10 m on a substrate that included silt, sand, gravel and larger rocks. In bays 10 and 11 there followed a similarly narrow zone of kelp (predominantly Laminaria spp.) that extended to depths of 4-5 m.

In all bays a relatively fresh surface layer of water was observed during both August and September. On many occasions a distinct boundary was observed at 3-4 m depths, whereas at other times the mixing of fresh and salt

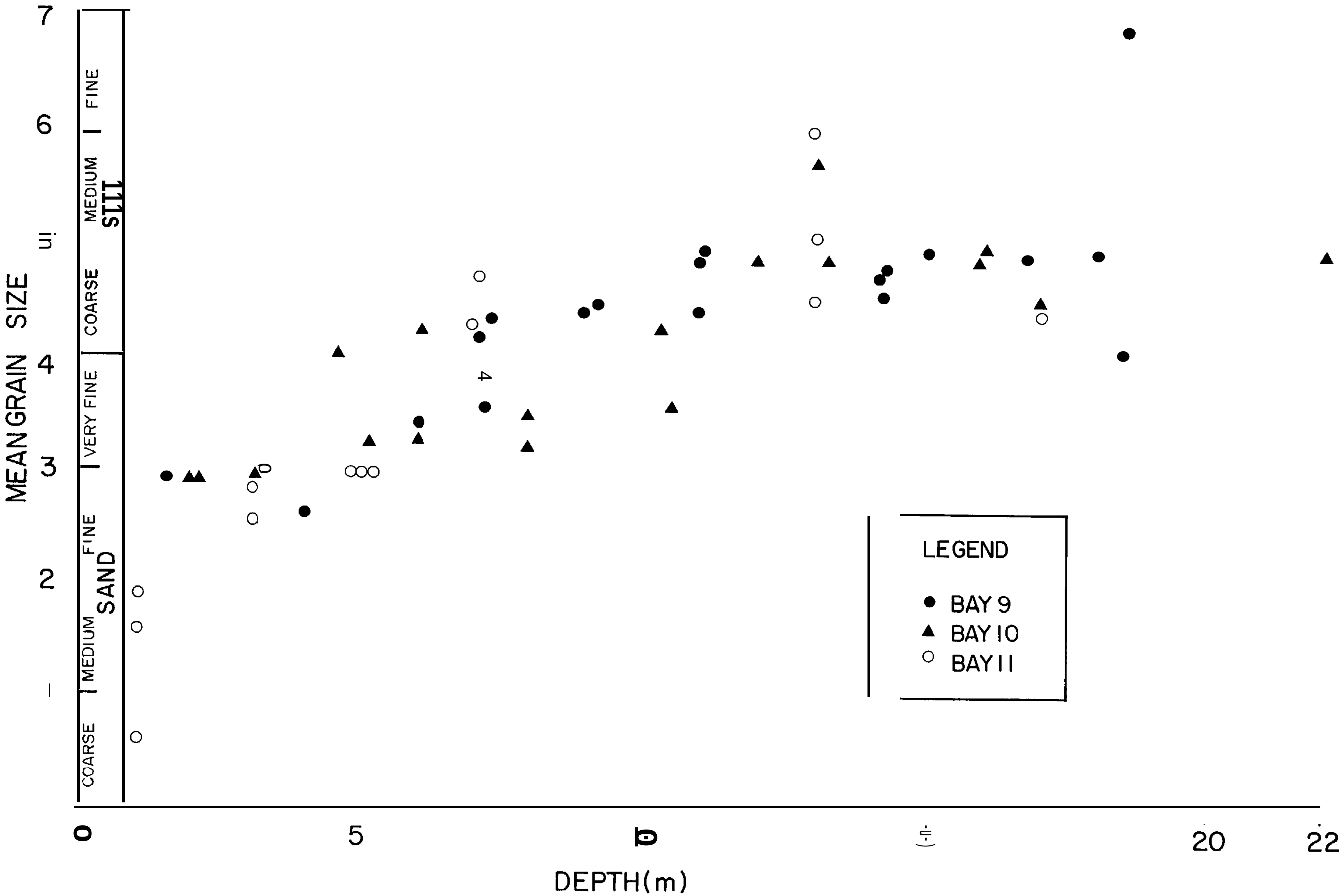

FIG. 3. Depth distribution of mean grain size in sediments from the three study bays at Cape Hatt, northern Baffin Island. Data were supplied by Barrie et al. 1981.

Table 1. Sediment characteristics and volume of sediment and rock sampled by airlift sampler at two depths in three bays at Cape Hatt, northern Baffin Island. For sediment characteristics (lines 1-3), n = 6 (column 2), 4 (col. 1), 3 (col. 5, 6) or 2 (col. 3, 4); for airlift samples (lines 4-6), n = 24 (all columns). Data sre expressed as mean ± SD.

	7mDepth			3m Depth		
	Bay 9	Bay 10	Bay 11	Bay 9	Bay 10	Bay 11
Mean grain size	3.89 ± 0.43	3.54 ± 0.42	4.50 ± 0.31	2.77 ± 0.22	2.95 ± 0.12	2.77 ± 0.14
Sorting coefficient	2.71 ± 0.45	2.41 ± 0.24	3.52 ± 0.04	2.27 ± 0.15	1.57 ± 0.08	2.97 ± 0,09
Skewness	1.48 ± 0.62	1.47 ± 0.40	0.68 ± 0.11	1.64 ± 0.70	2.96 ± 0.28	1.29 ± 0.08
Airlift penetration depth (cm)	16.4 ± 2.7	15.8 ± 3.7	16.9 ± 3.0	10.7 ± 2.7	11.2 ± 2.7	8.0 ± 2.8
Sediment volume[2] sampled (L)	8.5 ± 1.7	8.7 ± 2.0	9,8 ± 1.8	5.7 ± 1.8	5.6 ± 1.7	4.3 ± 1.7
Rock content of sample (kg)	4.3 ± 1.2	3.1 ± 1.3	1.9 ± 1.0	2.4 ± 0.9	3.3 ± 1.2	1.7 ± 0.9
Rock volume in total volume[3] (%)	16.8	12.6	7.2	14.4	18.9	13.6

1 From Barrie et al. 1981.
2 Not including rock.
3 Including reck.

water was apparent as deep as 7 or 8 m. Recent kills of bivalves, brittle stars, urchins and gastropod, probably resulting from this influx of fresh water, were observed at depths of 3-5 m during both August and September.

In the deeper (5-10 m) portion of the sublittoral zone in each bay, the substrate consisted of an unconsolidated silt veneer overlying a mixture of silt, sand, gravel and considerable amounts of cobble and rock. Sparsely distributed boulders and large rocks colonized by the kelps Laminaria sp. and Agarum cribrosum were common in bays 10 and 11, and less common in Bay 9. In all bays the conspicuous infauna were the bivalve Mya truncata and the fan worm Chone infundibuliformis, and fauna commonly occurring on the substrate surface included the urchin Strongylocentrotus droebachiensis, the sea star Leptasterias groenlandicus and several species of brittle stars. The relative densities of these and other organisms, less conspicuous due to size or habit, are presented in the following section.

RESULTS AND DISCUSSION

The benthos in the study bays at Cape Hatt is comprised of a wide variety of animals which, for the purposes of the present study, have been classified into two groups according to their relative mobility. The term infauna will be used to refer to those animals that are either incapable of motion or are only able to move slowly in the sediment or on the sediment surface. This group includes bivalves, polychaetes, gastropod, priapulids, nemerteans and some echinoderms. The term epibenthos will be used for those animals capable of relatively rapid motion, including amphipods, cumaceans and ostracods, and large echinoderms capable of moving relatively large distances on the sediment surface (urchins and starfish). Both of these groups are included in the infauna as defined by Thorson (1957).

The infauna and epibenthos (as defined above) will be treated separately in the present study. Most analysis and discussion will concern infauna, primarily because their relative immobility will expose them to the full impact of oil or dispersed oil and facilitate the interpretation of results. With mobile epibenthos, it is often impossible to distinguish between mortality and emigration as the cause of disappearance following an oilspill (e.g. Elmgren et al. 1980). Infauna are also of interest because of their dominance of total benthic biomass (99.4% in the study bays at Cape Hatt), and because of their long life spans in the Arctic (Curtis 1977; Petersen 1978). The latter further facilitates interpretation of results because it is indicative of reduced seasonal and annual variability.

Infauna

Sampling Efficiency

Preliminary sampling in August 1980 indicated that all of the species and most of the individuals found in the Cape Hatt benthic community could be sampled adequately with a sampler penetration depth of no more than 8 to 10 cm, However, a large proportion of the benthic biomass was contributed by large individuals of the bivalve *Mya truncata*, which occurred to depths of 15 cm in the sediment. Mean depth of penetration of the airlift sampler used in the present study was at least 15 cm at the 7 m depth in each of the bays (Table 1). Visual and tactile inspection of sampling plots by divers during and after sampling insured that all large individuals of Mya *truncata* were collected by the sampler. Sampler penetration was shallower at the 3 m depth in all bays (Table 1) due to the presence of a consolidated inpenetrable sediment layer and/or rock. Inspection of the sampling plots insured that all large individuals of *Mya truncata* were collected.

Although the area and depth of sediment sampled by the airlift could be accurately controlled by the divers, the amount of rock in the sampling plots was variable (Table 1) and hence the volume of sediment sampled was also variable. The effect of a variable volume of sediment on the abundance of infauna under a fixed area was assessed by regression analysis (BMDP1R, Dixon and Brown 1977). The biomasses and densities of polychaetes, bivalves and total infauna were regressed against volume of sediment removed by the airlift sampler minus the volume of rock. The results (Table 2) show that only the biomass of polychaetes in Bay 11 at 3 m and the biomasses of bivalves and total infauna in Bay 9 at 7 m were significantly related to variable sediment volume. Volume of rock in the sediment does not appear to have been a major factor influencing the quantity of animals collected in the samples.

Species-area curves are useful in determining the area that must be sampled in order to yield a representative estimate of the number of species present: The curves shown on Fig. 4 show the cumulative number of species that have been collected after an increasing number of samples has been considered at each depth in each bay. At both depths the curves flatten after 0.5 to 1.0 m^2 has been sampled. Depending on depth and bay, the number of species found in 1.0 m2 (16 samples) represented 87 to 98% of the total number of species collected in all 24 samples.

Table 2. Significance levels for regression of quantity of polychaetes, bivalves and total infauna Vs. volume of sediment sampled. Sedement volume adjusted for volume of rock; NS = P>0.01, ** = $P \leq 0.01$.

Taxon			7 m				3 m			
	Depth ->									
	Bay ->		9	10	11	Au	9	10	11	All
	Sample size ->		24	24	24	72	24	24	24	72
Polychaeta	(no./m^2)		NS	NS	NS	Ns	NS	NS	NS	NS
	(g/m^2)		NS	NS	NS	NS	NS	NS	**	NS
Bivalvia	(no./m^2)		NS	Ns	Ns	Ns	NS	NS	NS	Ns
	(g/m^2)		**	Ns	NS	Ns	NS	NS	NS	NS
Total infauna	(no./m^2)		NS	Ns	Ns	Ns	NS	Ns	Ns	NS
	(g/m^2)		**	NS	Ns	NS	NS	NS	NS	Ns

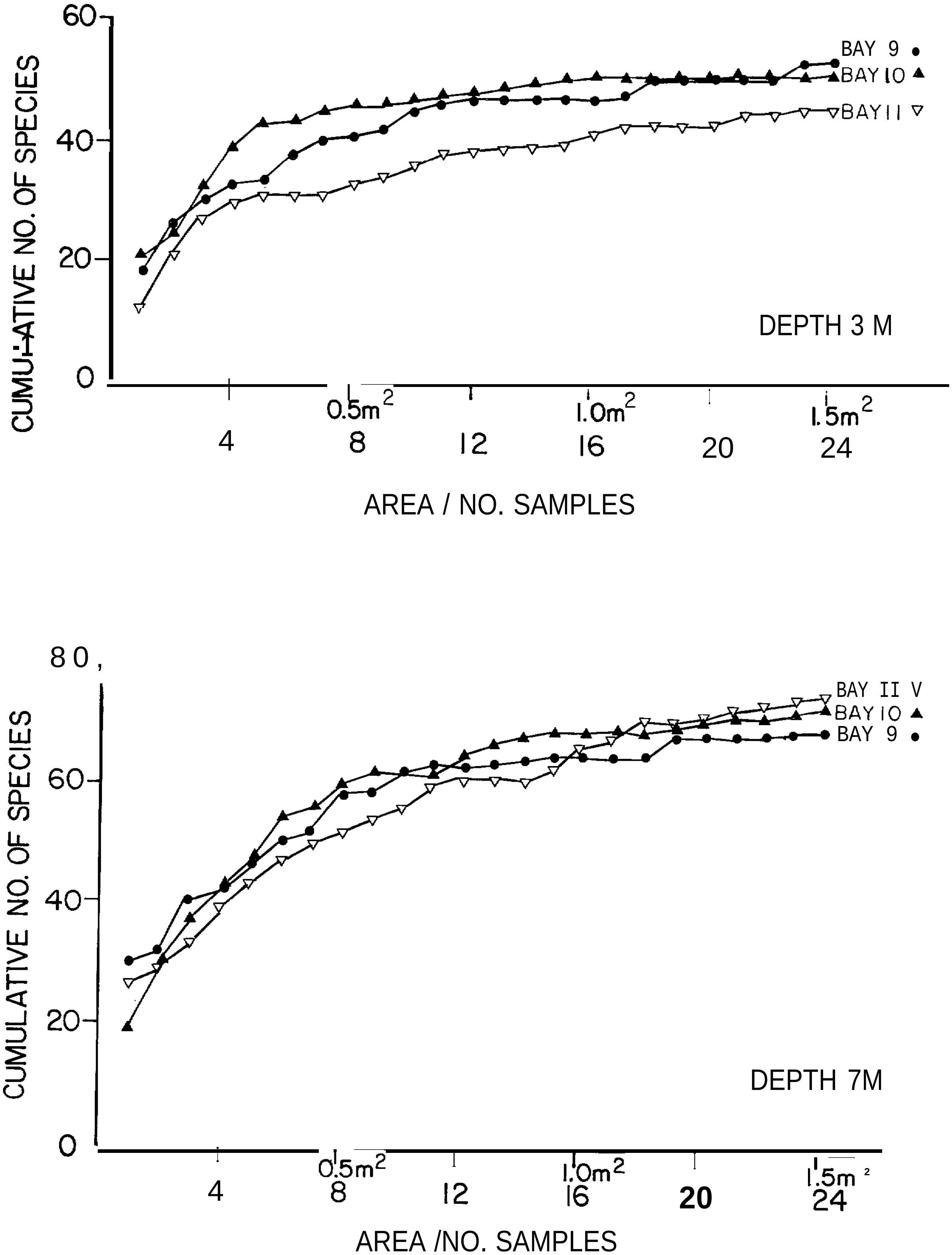

FIG. 4. Species-area curves for each of the three experimental bays at Cape Hatt, northern Baffin Island. Only the infauna is considered.

The penetration depth and the total area sampled by the airlift in each bay appear to be sufficient to yield samples that adequately represent the types and quantities of animals present.

Group and Species Composition

Group composition of the infauna collected in the study area at Cape Hatt (all bays and depths considered) is shown in Table 3. Bivalves accounted for most of the biomass (93,4%) and bivalves and polychaetes, in approximately equal proportions, accounted for most of the numbers of animals collected (85.6%).

The most common animals taken from samples at Cape Hatt are shown in Table 4. Twelve species accounted for 93.2% of the infaunal biomass and a partially overlapping list of 12 taxa accounted for 65.5% of the numbers of animals collected. Only four species were dominant (i.e. among the top 12 species) in terms of both biomass and density: *Mya truncata*, *Astarte borealis*, *Astarte montagui* and *Macoma calcarea* (Table 4).

In general, the benthos of the study area at Cape Hatt appears to be typical of that in nearshore high arctic areas. Several of the dominant infaunal species, including several of those contributing most to biomass (*Mya truncata*, *Macoma calcarea*, *M. moesta*, *Astarte borealis*, *A. montagui*, *Serripes groenlandicus*, and *Cistenides granulate*), belong to the arctic *Macoma* community (Thorson 1957; Ockelmann 1958; Ellis 1960; Thomson MS). This community is a widespread and common feature of nearshore high arctic areas and is displaced only under local circumstances (e.g. under estuarine

Table 3. Group composition of in fauna collected in the study bays at Cape Hatt, northern Baffin Island, during September 1980. Based on 144 samples, each covering 0.0625 m^2, from 3 and 7 m depths.

Taxon	% of total biomass	% of total density
Bivalvia	93.40	45.36
Polychaeta	3.75	40.27
Gastropod	1.14	8.27
Echinoidea	0.98	0.04
Holothuroidea	0.36	4.02
Ophiuroidea	0.15	0.06
Asteroidea	0.05	0.77
Ascidiacea	0.03	0.08
Other	0.14	1.11
Total infauna	1170.8 g/m^2	2904.9 $ind./m^2$

Table 4. Percent contribution to total infauna by dominant species in the study bays at Cape Hatt, northern Baffin Island. Based on 144 samples, each covering 0.625 m^2, from 3 and 7 m depths.

Biomass		Density	
Dominant species	% of total infauna	Dominant species	% of total infauna
Mya truncata (B)	50.9	Phloe minuta (P)	11.8
Astarte borealis (B)	18.4	Thyasiridae sp. (B)	8.3
Serripes groenlandicus (B)	8.4	Astarte borealis (B)	8.1
Astarte montagui (B)	4.4	Nereimyra punctata (P)	6.9
Hiatella arctica (B)	2.9	Mya truncata (B)	6.1
Macoma calcarea (B)	2.9	Astarte montagui (B)	5.1
Cistenides granulata (P)	1.1	Astarte sp. juveniles (B)	4.2
Strongylocentrotus droebachiensis (E)	1.0	Myriotrochus rinkii (H)	4.0
Musculus niger (B)	0.9	Euchone analis (P)	3.8
Musculus discors (B)	0.9	Chaetozone setosa (P)	2.8
Macoma moesta (B)	0.8	Cingula castanea (G)	2.2
Trichotropis borealis (G)	0.6	Macoma calcarea (B)	2.2
Total % contribution	93.2	Total % contribution	65.5
Biomass of all infauna (g/m^2)	1170.8	Density of all infauna ($no./m^2$)	2904.9

B = bivalve, P = polychaete, G = gastropod, H = holothurian, E = echinoid.

influences) . A quantitative analysis of community structure in the study bays is presented in a following section.

Biomass

Average infaunal biomass in the study area at Cape Hatt (all bays and depths considered) was 1171 g/m^2 (Table 4); at 3 m and 7 m depths, respectively, mean biomass was 328 g/m^2 and 2013 g/m^2. These values are considerably higher than mean depth-integrated biomass (5 to 50 m) in other arctic areas (Table 5).

Table 5. Mean depth-integrated biomass (g/m^2) of benthic infaunal animals from arctic areas. Only the depth range from 5 to 50 m is considered.

Location*	Sample size	Mean biomass (g/m^2)	Source
Alaskan Beaufort Sea	131	41	Carey (1977)
Bridport Inlet, Melville Is.	78	94	Buchanan et al. (1977)
Brentford Bay, Boothia Pen.	21	188	Thomson et al. (1978)
Lancaster Sound	110	319	Thomson and Cross (1980)
Northern Baffin Is.	51	200-438	Ellis (1960)

* Relatively high biomass (up to 1482 g/m^2) has aLso been reported at locations in West Greenland (Vibe 1939).

The apparently high infaunal biomass at Cape Hatt relative to that in other arctic locations is likely due largely to the effectiveness of our sampler. About half of the biomass found at the 7 m depth at Cape Hatt represented Mya truncata. Preliminary sampling indicated that this deeply burrowing species was only sampled effectively if the sediment was excavated to a depth of 15 cm. Buchanan et al. (1977) compared results of quantitative underwater photographs with those of shallow penetrating samples and found that their shallow samples underestimated infaunal biomass by as much as 960

g/m^2. Many of the other low values reported in Table 5 may also be due to inadequate sampling.

In most high arctic areas a barren zone extends from the shoreline to depths of 2 to 10 m. This zone is devoid of infauna except for the tunicate Rhizomolgula globularis, and is populated almost exclusively by motile amphipods. At Cape Hatt, however, a relatively high infaunal biomass consisting mainly of bivalves was found at the 3 m depth. Here and elsewhere in Eclipse Sound the barren zone occurs only at shallower depths, likely due to the relatively protected location (Thomson and Cross 1980).

Distribution--Analysis of Variance

At the end of the experiment, the overall test for an effect of oil and/or oil and dispersant will be a test for any change in benthic community composition. This test will be based on a multivariate analysis of variance (see below). This analysis will compare temporal changes (if any) in the experimental bays with temporal changes in the control bay. This overall test will be supplemented with similar analyses of the density and biomass of major infaunal groups and selected species. The analyses outlined in the present report describe the nature of variability of these groups and species under pristine conditions. These data on pre-spill conditions, along with similar data to be collected just before the spill in 1981, will be the basis against which post-spill data will be compared.

Mean density ($no./m^2$) and biomass (g/m^2) of bivalves, polychaetes, total infauna and species that are dominant either in terms of density or biomass are given in Tables 6 and 7. Considerable spatial variability is evident for most groups and species at all scales, viz. among samples within transects, among transects within depths and bays, between depths, and among bays. This section describes the results of statistical procedures used to examine the relative magnitudes and significance of these sources of variation. The smallest-scale variability, that among replicate samples within transects, is used as a basis of comparison for variation among transects. Among-transect variation, in turn, is used to determine the significance of variation among bays and between depths.

The smallest-scale variability in infaunal distribution that can be examined in the present study is that occurring among the eight samples (each covering 1/16 m^2) along each of the 50 m transects. The amount of within-transect variability is indicated by the coefficients of variation (CV = SD/Mean, expressed as a percent); a low CV is indicative of an even distribution; a high CV (e.g., where CV>100%) is indicative of a patchy distribution. For groups of species (bivalves, polychaetes and total infauna), the CV always was less than 100% at the 7 m depth, and usually was <100% at the 3 m depth (23 of 27 cases for biomass, 26 of 27 for density). The distributions of the individual species listed in Tables 6 and 7, however, were less even, especially at the 3 m depth. At 3 m, the CV for biomass was <100% in only 6 of 45 cases (13%), and that for density was <100% in only 27 of 50 cases (54%). At a depth of 7 m, the coefficient of variation for biomass was >100% in 35 of 54 species/transect combinations (65%), and that for density was >100% in 35 of 49 combinations (71%). A more detailed analysis of small-scale distribution will not be presented here, but inspection of the data in Tables 6 and 7 shows that distributions range from

Table 6. Mean density (no. /m²) of major taxa and dominant species of in fauna on transects at two depths in three bays at Cape Hatt, northern Baffin Island, during September 1980. Data are expressed as mean ± standard deviation and are based on 8 replicate 0.0625 m² airlift samples at each depth and transect.

Taxa	Transect	3 m Depth			7 m Depth		
		Bay 9	Bay 10	Bay 11	Bay 9	Bay 10	Bay 11
Total in fauna[1]	1	3226.0 ± 462.7	3494.0 ± 1548.0	1470.0 ± 1218.5	3866.0 ± 1082.5	2974.0 ± 1214.0	2790.0 ± 483.9
	2	3370.0 ± 950.4	2894.0 ± 653.3	1804.0 ± 764.3	3954.0 ± 1475.4	2772.0 ± 601.3	2562.0 ± 663.1
	3	4700.0 ± 832.0	2652.0 ± 448.0	1184.0 ± 379.0	2918.0 ± 1250.9	2774.0 ± 722.9	2884.0 ± 756.7
	All	3765.3 ± 1005.1	3013.3 ± 1025.2	1486.0 ± 860.4	3759.3 ± 1313.3	2840.0 ± 852.6	2745.3 ± 631.2
Polychaeta	1	2016.0 ± 407.7	1604.0 ± 529.4	840.0 ± 613.0	880.0 ± 235.0	884.0 ± 383.9	828.0 ± 252.7
	2	1536.0 ± 280.8	1760.0 ± 638.7	1174.0 ± 468.7	910.0 ± 363.2	948.0 ± 301.5	738.0 ± 217.8
	3	2086.0 ± 782.6	1432.0 ± 462.9	618.0 ± 229.0	850.0 ± 409.7	988.0 ± 325.4	962.0 ± 319.7
	All	1879.3 ± 568.7	1598.7 ± 541.7	877.3 ± 501.6	880.0 ± 329.7	940.0 ± 326.6	842.7 ± 271.7
Bivalvia	1	646.0 ± 245.3	1258.0 ± 789.1	228.0 ± 402.1	2656.0 ± 783.0	1850.0 ± 965.2	1718.0 ± 515.0
	2	992.0 ± 615.9	598.0 ± 327.0	418.0 ± 246.6	2388.0 ± 725.4	1676.0 ± 434.2	1526.0 ± 521.3
	3	1672.0 ± 371.5	866.0 ± 286.4	264.0 ± 139.2	1808.0 ± 760.6	1654.0 ± 635.4	1502.0 ± 498.6
	All	1103.3 ± 604.4	907.3 ± 568.9	303.3 ± 284.1	2284.0 ± 808.4	1726.7 ± 686.9	1582.0 ± 498.8
Mya truncata	1	278.0 ± 170.4	310.0 ± 337.7	60.0 ± 81.0	238.0 ± 61.3	208.0 ± 110.2	158.0 ± 65.4
	2	244.0 ± 205.6	180.0 ± 123.9	66.0 ± 55.7	170.0 ± 75.5	150.0 ± 90.9	162.0 ± 87.8
	3	326.0 ± 89.7	186.0 ± 76.9	46.0 ± 32.5	120.0 ± 73.1	100.0 ± 62.7	208.0 ± 107.5
	All	282.7 ± 159.1	225.3 ± 211.9	57.3 ± 57.8	176.0 ± 83.3	152.7 ± 97.2	176.0 ± 87.8
Astarte borealis	1	68.0 ± 124.5	80.0 ± 89.7	20.0 ± 40.8	372.0 ± 253.4	320.0 ± 295.8	454.0 ± 183.2
	2	196.0 ± 129.6	68.0 ± 127.4	18.0 ± 23.3	610.0 ± 257.2	354.0 ± 163.3	320.0 ± 131.4
	3	316.0 ± 102.2	24.0 ± 29.6	22.0 ± 28.3	290.0 ± 200.3	386.0 ± 216.9	334.0 ± 256.2
	All	193.3 ± 154.0	57.3 ± 90.9	20.0 ± 30.3	424.0 ± 266.6	353.3 ± 223.2	369.3 ± 198.0
Astarte montagui	1	8.0 ± 17.1	16.0 ± 39.2	2.0 ± 5.7	240.0 ± 228.8	142.0 ± 103.5	554.0 ± 245.3
	2	114.0 ± 118.6	0	4.0 ± 11.3	182.0 ± 105.1	126.0 ± 119.6	418.0 ± 286.1
	3	288.0 ± 198.0	0	0	114.0 ± 69.7	154.0 ± 91.3	306.0 ± 215.6
	All	136.7 ± 173.8	5.3 ± 23.0	2.0 ± 7.2	178.7 ± 153.4	140.7 ± 101.4	426.0 ± 261.0
Thyasiridae sp.	1	62.0 ± 77.2	178.0 ± 113.0	12.0 ± 28.0	740.0 ± 232.3	400.0 ± 265.7	88.0 ± 115.1
	2	230.0 ± 183.2	108.0 ± 75.4	0	518.0 ± 233.9	552.0 ± 210.7	62.0 ± 33.6
	3	370.0 ± 311.6	88.0 ± 96.0	12.0 ± 22.2	512.0 ± 186.2	348.0 ± 216.0	58.0 ± 75.0
	All	220.7 ± 241.1	124.7 ± 99.9	8.0 ± 20.6	590.0 ± 235.3	433.3 ± 238.8	69.3 ± 79.2
Euchone analis	1	236.0 ± 154.1	108.0 ± 127.9	160.0 ± 123.6	10.0 ± 22.5	2.0 ± 5.7	18.0 ± 32.5
	2	288.0 ± 155.8	258.0 ± 130.9	38.0 ± 43.6	2.0 ± 5.7	14.0 ± 23.3	0
	3	760.0 ± 744.1	52.0 ± 35.0	40.0 ± 41.9	0	2.0 ± 5.7	6.0 ± 17.0
	All	428.0 ± 491.0	139.3 ± 135.9	79.3 ± 95.7	4.0 ± 13.6	6.0 ± 14.8	8.0 ± 21.6
Myriotrochus rinkii	1	290.0 ± 201.9	160.0 ± 235.5	114.0 ± 124.9	104.0 ± 98.6	0	2.0 ± 5.7
	2	332.0 ± 180.4	148.0 ± 60.9	80.0 ± 49.9	92.0 ± 102.9	0	0
	3	428.0 ± 128.5	118.0 ± 60.4	82.0 ± 42.3	76.0 ± 111.4	2.0 ± 5.7	76.0 ± 99.6
	All	350.0 ± 175.5	142.0 ± 139.4	92.0 ± 79.4	90.7 ± 100.5	(3,7 ± 3.3	26.0 ± 65.9

[1] All taxa but ostracods, cumaceans and amphipods.

Table 7. Mean biomass (g/m²) of major taxa and dominant species of infauna on transects at two depths in three bays at Cape Hatt, northern Baffin Island, during September 1980. Data are expressed . . mean ± standard deviation and ... based on 10% formalin wet weight in 8 replicate 0.0625 m² airlift samples at each depth and transect.

Taxa	Transect	3 m Depth Bay 9	3 m Depth Bay 10	3 m Depth Bay 11	7 m Depth Bay 9	7 m Depth Bay 10	7 m Depth Bay 11
Total infauna[1]	1	254.8 ± 163.7	401.1 ± 297.1	113.4 ± 179.0	3632.7 ± 1115.9	1983.6 ± 1033.4	1388.6 ± 617.9
	2	596.5 ± 420.8	246.4 ± 184.0	93.3 ± 61.0	2959.2 ± 651.2	1383.9 ± 733.1	1728.1 ± 890.8
	3	936.5 ± 306.9	265.2 ± 154.7	43.2 ± 29.0	1934.5 ± 847.8	1423.7 ± 277.5	1689.3 ± 1073.2
	All	595.9 ± 414.2	304.2 ± 222.3	83.3 ± 109.8	2842.1 ± 111.5	1597.1 ± 768.3	1602.0 ± 855.7
Bivalvia	1	207.4 ± 160.0	341.2 ± 273.1	75.6 ± 141.8	3523.9 ± 1142.3	1879.9 ± 1036.7	1239.2 ± 595.6
	2	520.7 ± 423.1	209.9 ± 185.0	62.9 ± 57.0	2874.3 ± 672.3	1302.9 ± 750.4	1622.4 ± 886.5
	3	870.5 ± 296.2	233.2 ± 152.5	24.9 ± 25.4	1818.9 ± 842.9	1338.7 ± 269.0	1528.5 ± 1019.8
	All	535.5 ± 406.8	261.4 ± 208.8	54.5 ± 873.3	2739.0 ± 1125.2	1507.2 ± 770.2	1463.4 ± 831.5
Polychaeta	1	33.2 ± 13.0	47.3 ± 30.0	18.7 ± 19.0	48.8 ± 39.8	61.9 ± 46.8	45.1 ± 19.2
	2	44.8 ± 13.1	29.1 ± 12.6	25.2 ± 12.3	66.0 ± 39.2	75.0 ± 51.4	42.9 ± 22.2
	3	40.6 ± 16.2	23.0 ± 9.2	11.6 ± 4.8	49.7 ± 33.6	54.4 ± 29.2	72.4 ± 35.0
	All	39.5 ± 14.4	33.1 ± 21.4	18.5 ± 14.0	54.8 ± 36.9	63.8 ± 42.5	53.5 ± 28.7
Mya truncata	1	150.3 ± 159.6	176.7 ± 235.2	38.2 ± 82.2	2314.5 ± 1048.6	1018.6 ± 792.3	517.0 ± 492.6
	2	250.9 ± 180.7	156.2 ± 169.4	9.6 ± 8.4	1528.8 ± 750.1	728.0 ± 583.2	1066.8 ± 679.7
	3	334.5 ± 165.1	97.4 ± 101.4	4.8 ± 7.6	1149.4 ± 492.4	430.8 ± 287.2	756.6 ± 680.3
	All	245.2 ± 178.6	143.4 ± 172.8	17.6 ± 48.2	1664.2 ± 908.5	725.8 ± 616.2	780.1 ± 638.9
Astarte borealis	1	13.5 ± 22.2	54.6 ± 104.9	4.4 ± 8.6	293.5 ± 275.1	366.6 ± 464.9	404.0 ± 240.7
	2	164.9 ± 182.9	15.3 ± 27.0	19.9 ± 44.2	475.2 ± 375.6	287.9 ± 218.6	256.8 ± 225.9
	3	339.4 ± 121.2	28.8 ± 46.0	10.3 ± 17.6	189.5 ± 120.2	426.6 ± 222.9	528.8 ± 734.6
	All	172.6 ± 182.5	32.9 ± 67.0	11.6 ± 27.4	319.4 ± 291.4	360.4 ± 314.4	396.5 ± 458.6
Astarte montagui	1	1.5 ± 2.9	9.3 ± 19.3	0.3 ± 0.7	78.1 ± 84.3	43.3 ± 26.8	177.7 ± 78.8
	2	49.9 ± 56.6	0	0.1 ± 0.2	50.7 ± 42.3	45.9 ± 44.8	154.6 ± 119.9
	3	98.3 ± 75.1	0	0	45.6 ± 45.0	64.9 ± 56.0	109.7 ± 77.4
	All	49.9 ± 65.7	3.1 ± 11.5	0.1 ± 0.4	58.2 ± 59.5	51.4 ± 43.4	147.3 ± 94.5
Serripes groenlandicus	1	13.2 ± 21.8	0	6.6 ± 18.7	429.0 ± 267.6	189.2 ± 182.6	15.4 ± 31.1
	2	21.5 ± 37.7	3.5 ± 9.8	0	462.5 ± 558.2	110.1 ± 193.5	40.0 ± 79.9
	3	6.1 ± 15.3	0	0	190.1 ± 98.2	260.4 ± 238.4	29.8 ± 67.7
	All	13.6 ± 26.3	1.2 ± 5.7	2.2 ± 10.8	360.5 ± 367.3	186.6 ± 206.8	28.4 ± 61.1
Hiatella arctica	1	26.4 ± 35.2	53.9 ± 97.3	1.4 ± 3.3	185.5 ± 207.3	4.0 ± 5.7	13.0 ± 36.7
	2	18.2 ± 31.4	15.5 ± 41.3	8.5 ± 20.9	109.2 ± 127.8	0.3 ± 0.9	0.1 ± 0.1
	3	57.5 ± 74.1	0.9 ± 1.8	0.1 ± 0.2	85.4 ± 241.6	14.9 ± 27.8	10.4 ± 24.1
	All	34.0 ± 51.5	23.4 ± 62.6	3.3 ± 12.3	126.7 ± 194.2	6.4 ± 16.9	7.8 ± 24.9
Macoma calcarea	1	0.2 ± 0.7	6.3 ± 8.8	7.2 ± 10.1	100.5 ± 40.1	60.2 ± 38.5	54.3 ± 28.6
	2	11.2 ± 21.7	6.2 ± 7.6	0	68.0 ± 44.3	70.0 ± 48.3	33.9 ± 36.0
	3	15.7 ± 15.0	1.2 ± 1.8	0	50.7 ± 22.9	70.8 ± 41.6	47.9 ± 48.1
	All	9.0 ± 16.0	4.6 ± 6.9	2.4 ± 6.6	73.1 ± 41.1	67.0 ± 41.4	45.4 ± 37.7

[1] All taxa but ostracods, cumaceans and amphipods.

relatively even to relatively patchy, depending on species. The number of species for which data are presented is admittedly small, and even greater extremes in variability are expected among the large number of less common species that occur in the study area.

Two types of nested analysis of variance were carried out: two-factor (bays, depths) analyses in which all data were included, and one-factor (bays) analyses in which data from the two depths were analyzed separately. In each case transects were nested within bays and (if considered together) depths. An additional source of variation in the two-factor analysis is the interaction between bay and depth effects. Where this term is significant, the pattern of among-bay variation differs from depth to depth; in this circumstance the interpretation of main effects (bay and depth) is confounded, and separate one–factor analyses must be carried out. In the following sections the results of both one- and two-factor ANOVAs are presented.

Transect Effects

Of the three groups of organisms whose densities and biomasses were examined by ANOVA (bivalves, polychaetes and total infauna), variation among transects was significant only in the case of bivalve density (Table 8). However, among the individual species whose densities were examined, among-transect variation was significant for all but *Mya truncata.* For each of these cases where two-factor ANOVA indicated significant among–transect variation, one-factor ANOVA’s showed the variation to be significant at only one of the two depths. Densities of total bivalves, *Astarte montagui*,

Table 8. One- and two-factor[1] analyses of variance (ANOVA) for the biomasses and densities of major taxa and selected infaunal species in the study bays at Cape Hatt. Transects are nested within depths and bays; bay, depth and bay-depth interaction effects are tested over the transect MS, and transect ef feets ever the residual MS. F-values are shown with associated significance levels (ns = P>0 .01; ** P≤0.012, *** P≤0.001).

		Two-factor analyses (3 and 7 m depth, n = 144)				One-factor analyses[3]			
						3 m depth (n = 72)		7 m depth (n = 72)	
Source of variation ->		Bay	Depth	Bay X Depth	Transect	Bay	Transect	Bay	Transect
df ->		2,12	1,12	2,12	12,126	2,6	6,63	2,6	6,63
Biomass (g/m^2)	Total infauna	10.07[2]	36.772	8.18 **	1.84 ns	17.21 **	2.05 ns	8.28 ns	1.27 ns
	Polychaeta	5.91 ns	31.32 ***	6.04 ns	1.46 ns	8.81 ns	1.66 ns	0.69 ns	1.21 ns
	Bivalvia	22.492	143.932	9.16 **	1.83 ns	16.95 **	2.01 ns	8.74 ns	1.17 ns
Density ($no./m^2$)	Total infauna	28.12	8.462	14.59 ***	1.31 ns	28.79 ***	1.44 ns	3.52 ns	1.06 ns
	Polychaeta	13.27[2]	28.43[2]	10.65 **	1.43 na	14.17 **	2.17 na	0.79 ns	0.52 na
	Bivalvia	10.18 **	45.90 ***	5.47 na	2.98 **	8.00 ns	3.43 **	5.29 ns	1.04 ns
	Mya truncata	16.88[2]	8.17[2]	19.19 ***	0.80 na	33.13 ***	0.49 ns	0.37 ns	2.% ns
	Astarte borealis	4.24 ns	52.46 ***	3.62 ns	2.95 **	4.23 ns	3.10 ns	0.23 ns	1.87 ns
	Astarte montagiu	4.80 ns	62.48 ***	6.16 ns	5.95 ***	5.09 ns	10.27 ***	10.82 ns	0.90 ns
	Thyasiridae spp.	27.80 ***	36.08 ***	1.33 ns	3.16 **	11.16 **	3.58 **	53.03 ***	1.36 ns
	Euchone analis	2.16 ns	104.46 ***	3.67 ns	3.01 **	4.15 ns	3.92 **	0.20 ns	2.00 ns
	Myriotrochus rinkii	12.76 **	53.17 ***	1.28 ns	2.90 **	5.41 ns	2.11 na	7.81 ns	3.56 **

[1] One- factor ANOVA (bays) for each depth; two-factor ANOVA for bays and depths.
[2] Ambiguous because of significance of bay-depth interaction term.

Thyasiridae spp. and Euchone analis were variable only at the 3 m depth, and the density of Myriotrochus rinkii varied significantly only at the 7 m depth. Among-transect variation in the density of Astarte borealis was not significant at either depth when separate one-factor ANOVA's were considered.

Depth Effects

The significance of the bay-depth interaction effect in many groups and species tested precluded unambiguous interpretation of depth effects for these taxa, but the interaction itself can be considered to be indicative of a depth effect. For all other groups and species where no significant interaction occurred (biomass of polychaetes; densities of bivalves, Astarte borealis, Astarte montagui, Thyasiridae spp., Euchone analis and Myriotrochus rinkii), variation between depths was highly significant ($P<0.001$). Inspection of density and biomass data (Tables 6 and 7) shows that all of these bivalves (including total bivalves) were more abundant, and the biomass of polychaetes was higher, at the 7 m depth. On the other hand, the polychaete E. analis and the holothurian M. rinkii were more abundant at the 3 m depth. Table 7 also indicates that there were higher bivalve biomasses on the deeper transects for Serripes groenlandicus and Macoma calcarea (not tested) and for Mya truncata and total bivalves (significant interaction effects). In the last two cases biomass was higher at 7 m than at 3 m in all bays, but disproportionately so in one bay (>25 x higher at 7 m) than in the other two bays (5.1-6.8 x higher).

Bay Effects

For all groups and species where the bay-depth interaction term was significant (biomass of bivalves and total infauna; density of polychaetes, total infauna and *Mya truncata*), variation among bays was significant at the 3 m depth but not at the 7 m depth (Table 8). Among the remaining groups and species (those with no significant bay-depth interaction), no significant variation among bays was evident in the biomass of polychaetes or in the density of *Astarte borealis*, *A. montagui* and *Euchone analis*. On the other hand, the densities of bivalves, Thyasiridae spp. and *Myriotrochus rinkii* did vary significantly among bays. Results of one- and two-factor ANOVAs were consistent for all cases except the densities of bivalves and *M. rinkii*, where the among-bay variation evident in two-factor ANOVAs was significant at neither depth based on one-factor ANOVAs.

Capitella capitata

The polychaete worm *Capitella capitata* is an opportunistic species that is often used as an indicator of pollution (Grassle and Grassle 1977; Pearson and Rosenberg 1978). After an oil spill in Buzzards Bay, Massachussets, *C. capitata* 'monopolized the biologically denuded substrata at the heavily oiled stations for the first eleven months after the spill' (Sanders et al. 1980). At Cape Hatt, the mean density of *Capitella capitata* in all samples was 27.7 * SD 71.5 indiv./m^2 (n = 144). It appeared to be most abundant in shallow water, especially in Bay 9 (Table 9).

Table 9. Mean density ± SD (indiv./m^2) of _Capitella capitata_ on transects at two depths in three bays at Cape Hatt, northern Baffin Island. n = 8 for each transect.

	3 m Depth			7 m Depth		
Transect	Bay 9	Bay 10	Bay 11	Bay 9	Bay 10	Bay 11
1	52.0 ± 82.4	52.0 ± 49.7	42.0 ± 27,0	24.0 ± 30.8	8.0 ± 8.6	14.0 ± 15.9
2	106.0 ± 261.9	52.0 ± 28.0	8.0 ± 17.1	18.0 ± 21.7	26.0 ± 41.8	8.0 ± 12.1
3	4.0 ± 7.4	14.0 ± 15.9	10.0 ± 22.5	0.0 ± 0.0	48.0 ± 79.8	12.0 ± 16.6
All	54.0 ± 157.4	39.3 ± 37.4	20.0 ± 26.8	14.0 ± 23.3	27.3 ± 52.6	11.3 ± 14.5

Two factor, nested ANOVA showed that the density of this species differed significantly among transects ($F = 0.005$, $df = 12,126$; $P = 0.005$) indicating a patchy distribution. Variations among bays and between depths, however, were not significant (for bays $F = 2.29$, $df = 2,12$; $P = 0.144$; and for depths $F = 0.94$, $df = 1,12$; $P = 0.351$). The occurrence of this species in the experimental bays at Cape Hatt is fortuitous. Changes in the density of this species as the experiment progresses will be closely monitored.

Size-Frequency Distribution

Exposure to oil may cause size-selective mortality of benthic animals in a variety of ways. Not all life stages of marine animals are equally susceptible to the effects of oil (Rice et al. 1975; Linden 1978). Larval stages are generally more susceptible than are adults (Wells and Sprague 1976). Dow (1978) has demonstrated, on the other hand, an instance of selective mortality of large individuals of a bivalve. The juveniles inhabited clean surface sediments, but as they grew they tended to burrow deeper into the substrate and died when they reached an oil-contaminated layer.

Mean lengths of four bivalve species and oral ring diameters of a holothurian are shown in Table 10. Mean lengths (log transformed) of individuals in each sample were compared among bays and depths, using one- and two-factor nested ANOVAs (Tables 11 to 15). Insufficient data from some bays and depths precluded all-inclusive analyses for three of the species. For species in which mean lengths differed between depths (*Mya truncata*,

Table 10. Mean lengths (mm) of five species of in faunal benthic animals from three bays at Cape Hatt, northern Baffin Island.

Species		7 m Bay 9	7 m Bay 10	7 m Bay 11	3 m Bay 9	3 m Bay 10	3 m Bay 11	7 m Al 1	3 m Al 1
Mya truncata	$\bar{x}$	28.0	19.3	17.6	12.6	9.9	8.9	21.8	11.1
	SD	13.9	13.6	13.0	7.5	7.8	5.4	14.3	7.6
	n	222	178	224	369	296	79	624	744
Macoma calcarea	$\bar{x}$	13.0	15.2	15.2	11.9	10.7	19.4	14.1	11.9
	SD	5.5	6.8	6.9	5.1	4.7	3.8	6.3	5.3
	n	253	146	88	42	29	5	487	76
Astarte borealis	$\bar{x}$	12.7	13.2	13.6	12.8	8.1	10.9	13.1	11.7
	SD	7.0	8.5	8.6	7.5	8.7	7.5	8.0	8.0
	n	633	527	551	290	86	29	1711	405
Astarte montagui	$\bar{x}$	9.8	9.9	10.0	11.1	12.6	5.7	9.9	11.1
	SD	3.5	4.0	3.8	2.7	2.7	3.1	3.8	2.8
	n	268	209	638	205	8	3	1115	216
Myriotrochus rinkii[1]	$\bar{x}$	3.15	4.00	3.56	2.29	2.74	2.70	3.25	2.46
	SD	1.03		0.79	1.06	1.06	1.00	0.99	1.07
	n	136	1	39	517	210	137	176	864.00

[1] Diameter of calcareous oral ring.

Table 11. Results of analyses of variance on mean lengths in each sample of _Mya truncata_ and _Astarte borealis_ from three bays at Cape Hatt, northern Baffin Island.

Source	_Mya truncata_				_Astarte borealis_			
	df	MS	F	P	df	MS	F	P
Among bays	2,12	0.5387	14,82	0.001	2,12	0.0212	0.79	0.476
Between depths	1,12	2.5558	70.32	0.000	1,12	0.2884	10.75	0.007
Bay x depth interaction	2,12	0.0980	2.70	0.108	2,12	0.0801	2.99	0.088
Among transects within bays	12,124	0.0363	1.29	0.279	12,101	0.0268	0.74	0.709
Error	124	0.0282			101	0.0360		

Table 12. Results of analyses of variance on mean lengths in each sample of _Macoma calcarea_ and _Astarte montagui_ from three bays at Cape Hatt, northern Baffin Island. Only samples from 7 m depth are considered.

Source	_Macoma calcarea_				_Astarte montagui_			
	df	MS	F	P	df	MS	F	P
Among bays	2,6	0.0212	0.98	0.428	2,6	0.0014	0.26	0.779
Among transects within bays	6,63	0.0217	1.39	0.233	6,61	0.0054	0.70	0.651
Error	63	0.0157			61	0.0078		

Table 13. Results of analysis of variance on the mean oral ring diameter in each sample of the holothurian _Myriotrochus rinkii_ from three bays at Cape Hatt, northern Baffin Island. Only samples from 3 m depth are considered.

Source	df	MS	F	P
Among bays	2,6	0.0344	7.01	0.027
Among transects within bays	6,57	0.0049	0.60	0.729
Error	57	0.0082		

Table 14. Results of analyses of variance on mean lengths in each sample of *Astarte montagui* and *Myriotrochus rinkii* from Bay 9 at Cape Hatt, northern Baffin Island.

Source	*Astarte montugui*				*Myriotrochus rinkii*			
	df	MS	F	P	df	MS	F	P
Between depths	1,35	0.0148	2.69	0.110	1,36	0.2443	32.53	0.000
Among transects	2,35	0.0004	0.07	0.933	2,36	0.0150	2.00	0.150
Transect x depth interaction	2,35	0.0064	1.15	0.328	2,36	0.0248	3.30	0.048
Error	35	0.0055			36	0.0075		

Table 15. Results of analysis of variance on mean lengths in each sample of the bivalve *Macoma calcarea* from Bays 9 and 10 at Cape Hatt, northern Baffin Island.

Source	df	MS	F	P
Among bays	1,8	0.0183	0.80	0.397
Between depths	1,8	0.1969	8.57	0.019
Bay x depth interaction	1,8	0.0247	1.08	0.329
Among transects within bays	8,60	0.0230	1.78	0.099
Error	60	0.0129		

Astarte borealis, Myriotrochus rinkii), the larger animals were found at the deeper depth. Mean length differed among bays only in the case of *Mya truncata*. The largest individuals were found in Bay 9. Patchiness (variability among transects within bays and depths) was not significant for any species on the scale tested (50 m), apparently due to rather high within-transects variability. In none of the three instances where tests involving more than one bay were possible was there a significant bay by depth interaction. Thus the main factor related to size was water depth.

In Lancaster Sound and Eclipse Sound, Thomson and Cross (1980) also found some bivalve species to be smaller in shallow water, and attributed this to periodic mortality of shallow water animals. One cause of mortality in the Cape Hatt area could be an effect of the rather pronounced freshwater influence in the bays. Mortality of shallow water animals was in fact observed during the present study (see ‘Site Descriptions’).

Length-Weight Relationships of Bivalves

Exposure to crude oil may cause physiological changes in marine invertebrates . In bivalves these changes may be reflected in the length-dry weight relationship (Stekoll et al. 1980). The length–dry weight relationship of three bivalve species will be used as an indicator of sublethal effects of oil in the experimental bays at Cape Hatt.

For three species of bivalves, approximately 50 individuals from each of the three bays were measured and weighed. These animals were taken from the middle transect at 7 m depth in each bay:

Species	Sample size	Length (mm)		Dry meat weight (g)	
		Mean	Range	Mean	Range
Mya truncata	144	18.5	3-49	0.119	0.001-5.021
Macoma calcarea	132	12.7	3-28	0.022	0.001-0.230
Astarte borealis	152	12.9	3-38	0.018	0.001-0.467

Analysis of scatter plots of the original data and of residuals produced by regresson analyses indicated that the length-weight relationship of these animals was best expressed by a power curve ($y = ax^b$) rather than by exponential (y = sex), linear ($y = a + bx$) or logarithmic ($y = a \log x$) functions. Length-weight relationships are shown in Fig. 5.

The resultant regression equations (Table 16) explained, on the basis of the variable length, 86 to 98% of the variance of dry meat weight. Apparent among-bay differences in the slopes and intercepts of the regression lines were assessed with analysis of covariance. Significant ($P<0.01$) among-bay differences were evident in the slopes of the regression lines for Mya truncata and Astarte borealis (Table 16). Individuals of Mya truncata from Bay 10 and Astarte borealis from Bay 9 do not gain as much weight with increasing length as do individuals of the same species from other bays. These differences preclude the second step of the analysis of covariance--the test for differences in mean weight of individuals among bays after compensating for the effect of length on weight. For Macoma calcarea, the among-bay differences in the slope of the length-dry weight regression were not significant (Table 16). After adjusting for length-weight relationships, there was no significant among-bay difference in the dry meat weight of Macoma calcarea.

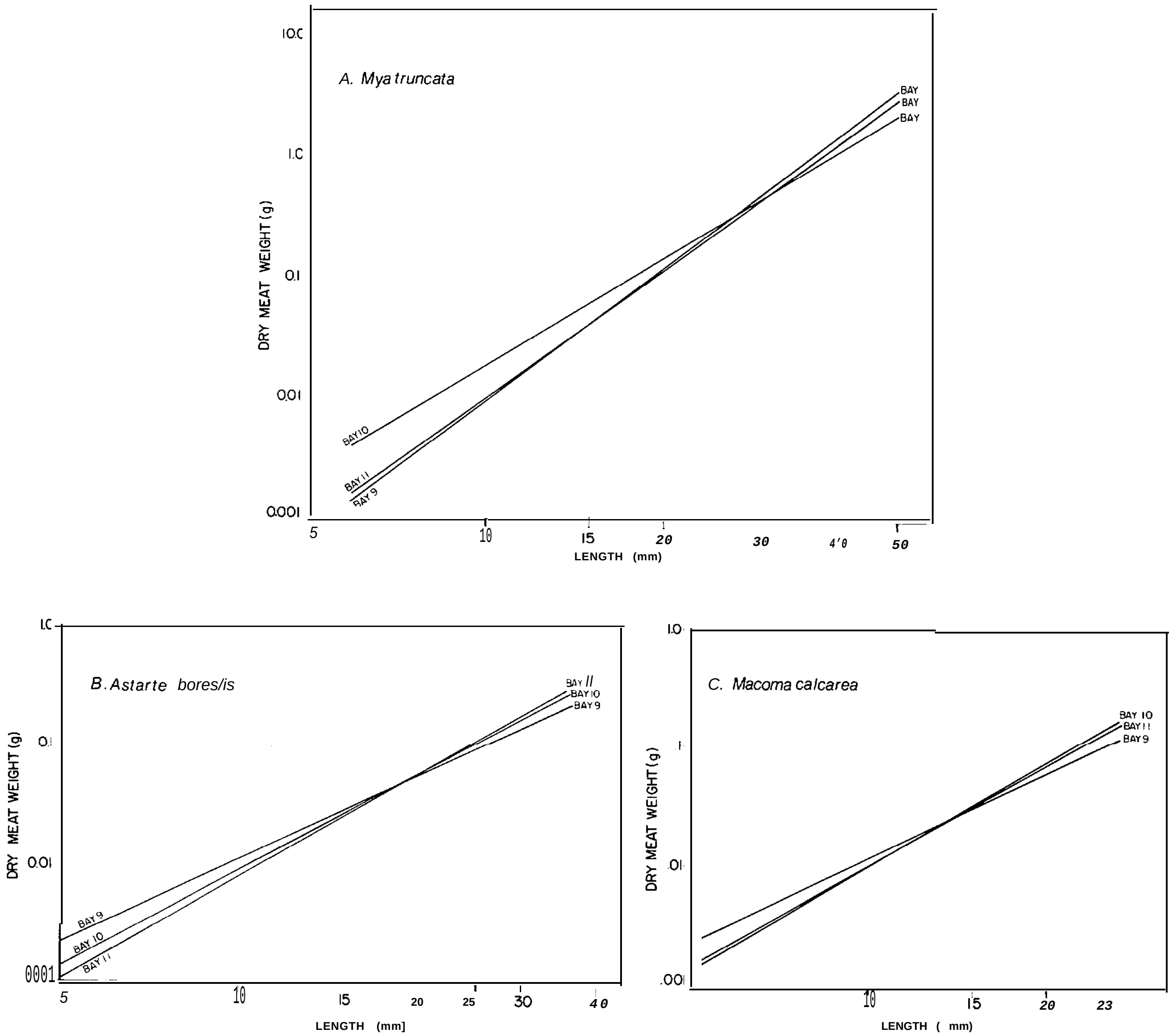

FIG. 5. Least squares regression lines of dry meat weight vs. length for (A) *Mya truncata,* (B) *Astarte borealis* and (C) *Macoma calcarea* from three bays at Cape Hatt, northern Baffin Island.

Table 16. Regressions and analyses of covariance for the length-dry meat weight relationships of three species of bivalve molluscs from three bays at Cape Hatt, northern Baffin Island.

	Regression			Covariance			
	Equation[1]	Correlation Coefficient[2] r	Sample size	Adjusted group means (Σ Log wt./n)[3]	Linearized group means (g)[4]	Test of equality of group means	Test of equality of slopes
Mya truncata							
Bay 9	$y = 2.28 \times 10^{-6} x^{3.696}$	0.989	47	-0.93571	0.116		
Bay 10	$y = 14.31 \times 10^{-6} x^{3.112}$	0.929	47	-0.85566	0.139	F= 2.24[5] (df = 2,140)	F = 8.35 (df = 2,138) p= 0.000
Bay 11	$y = 1.78 \times 10^{-6} x^{3.761}$	0.991	50	-0.97601	0.106		
Macoma calcarea							
Bay 9	$y = 3.88 \times 10^{-5} x^{2.493}$	0.957	50	-1.65140	0.022		
Bay 10	$y = 1.46 \times 10^{-5} x^{2.873}$	0.980	45	-1.65293	0.022	F= 0.03 (df = 2,128) p= 0.975	F= 4.42 (df = 2,126) p= 0.014
Bay 11	$y = 1.66 \times 10^{-5} x^{2.830}$	0.980	37	-1.65815	0.022		
Astarte borealis							
Bay 9	$y = 5.35 \times 10^{-5} x^{2.300}$	0.968	50	-1.70059	0.020		
Bay 10	$y = 2.10 \times 10^{-5} x^{2.626}$	0.986	50	-1.75567	0.018	F= 4.37[5] (df = 2,148)	F= 11.36 (df = 2,146) p = 0.000
Bay 11	$y = 1.25 \times 10^{-5} x^{2.792}$	0.984	52	-1.79281	0.016		

[1] y = dry meat weight (g); x= length (mm).
[2] Determined using a log transformation of both variables. The percent of variance explained is $100r^2$.
[3] Mean transformed weight adjusted for the slope of the regression.
[4] Back transformed weight adjusted for the slope of the regression.
[5] Statistical significance not directly testable because of among-bay difference in slopes.

Community Structure

Perturbation of the benthic marine environment often results in large scale changes in the infaunal community structure (Pearson and Rosenberg 1978). Faunal changes resulting from the introduction of oil may be drastic and the degree of change is related to the intensity and duration of oiling (Sanders et al 1980). One of the best approaches to detecting oil effects appears to be the community, or ecosystem approach (Mann and Clark 1978; Elmgren et al. 1980).

The relative change in species composition resulting from the experimental introduction of crude oil and crude oil plus a dispersant into two bays at Cape Hatt will be assessed with a multivariate analysis of variance (MANOVA). The following analyses were performed to describe the benthic community structure and its spatial variability under pristine conditions. Factor analysis was used to identify recurring groups of species and to reduce the dimensionality of the large number of possibly intercorrelated variables presented to the MANOVA.

The species considered in the analysis were those that accounted for at least 1% of the total number of infauna collected in any bay at either depth. In this way, 35 species were selected; together, these comprised 89.3% of the total number of infauna collected. Either density or biomass data would be adequate for the detection of large scale change, but subtle faunal changes would be more readily detected in density data. The biomass data are dominated by the presence and abundance of older individuals and would be relatively insensitive to numerical changes in younger individuals. Hence analyses were performed on density data.

The correlation matrix of transformed species abundances was calculated; principal components were then extracted from this matrix, and finally factors were generated by Varimax rotation. Eight factors were extracted (8 principle components had eigenvalues >1); these eight factors accounted for 65.2% of the variance represented by the 35 species variables. Each of these factors can be considered as representing a group of species that tend to occur together and whose densities vary more or less proportionately.

The results of the factor analysis are summarized in Table 17. This table lists the species whose densities were strongly correlated with each of the eight factors. Species that were strongly and positively correlated with any one factor tended to occur together. A measure of the abundance of each such group in a particular sample can be obtained by calculating the corresponding 'factor score' . A factor score is a linear, additive function of the original variables (log-transformed species densities), with each variable weighted proportionately to its correlation with the factor. A high factor score indicates that the group of species represented by the factor is common in the sample in question; a low or negative factor score indicates that those species are rare or absent. The mean factor scores for samples from each transect, bay and depth are shown in Fig. 6.

The first factor, representing mostly the bivalves, was the dominant assemblage in the samples; it accounted for 28% of variance represented in the 35 species variables. It was prominent on almost all transects at the 7 m depth (Fig. 6). This assemblage is very similar to the high arctic Macoma community described by Thorson (1957) and reported from other Canadian high arctic areas (Ellis 1960; Sekerak et al. 1976; Thomson MS).

Table 17. Results of factor analysis of the 35 most abundant benthic animals collected at Cape Hatt, northern Baffin Island, during September 1980. The values shown are the correlations between the Log transformed densities of various species (the original variables) and each of the 8 factors determined in the analysis. Species whose densities were weakly correlated with a factor $(-0.4 < r < 0.4)$ are not shown.

1.	
Astarte montagui	0.827
Macoma calcarea	0.806
Astarte borealis	0.790
Nuculana minuta	0.749
Macoma juveniles	0.720
Cistenides granulata	0.698
Trichotropis borealis	0.692
Astarte juveniles	0.673
Thyasiridae sp.	0.634
Macoma moesta	0.593
Aricidea sp.	0.553
Maldane sarsi	0.540
Phloe minuta	0.473
Serripes groenlandicus	0.415
Mya truncata	0.453
Scoloplos anniger	0.449
Proxillella proetermissa	0.498
Nereimyra punctata	-0.599
Euchone analis	-0.464

2.	
Myriotrochus rinkii	0.752
Retusa obtusa	0.724
Phloe minuta	0.594
Chaetozone setosa	0.543
Euchone analis	0.538
Cingula castanea	0.484

3.	
Musculus niger	0.670
Serripes groenlandicus	0.669
Owenia fusiformis	0.661
Nereimyra punctata	-0.427
EtOne longs	-0.452

4.	
Terebellides stroemi	0.832
Ampharetidae (unidentified)	0.655
Mya truncata	0.559
Cingula castanea	0.419

5.	
Musculus juveniles	0.872
Musculus discors	0.765

6.	
Capitella capitata	0.759
Ophelia limacina	0.454
Hiatella arctica	0.406

7.	
Harmothoe imbricata	0.720
Gastropod species G	-0.678

8.	
Scoloplos armiger	0.614
Thyasiridae sp.	0.499

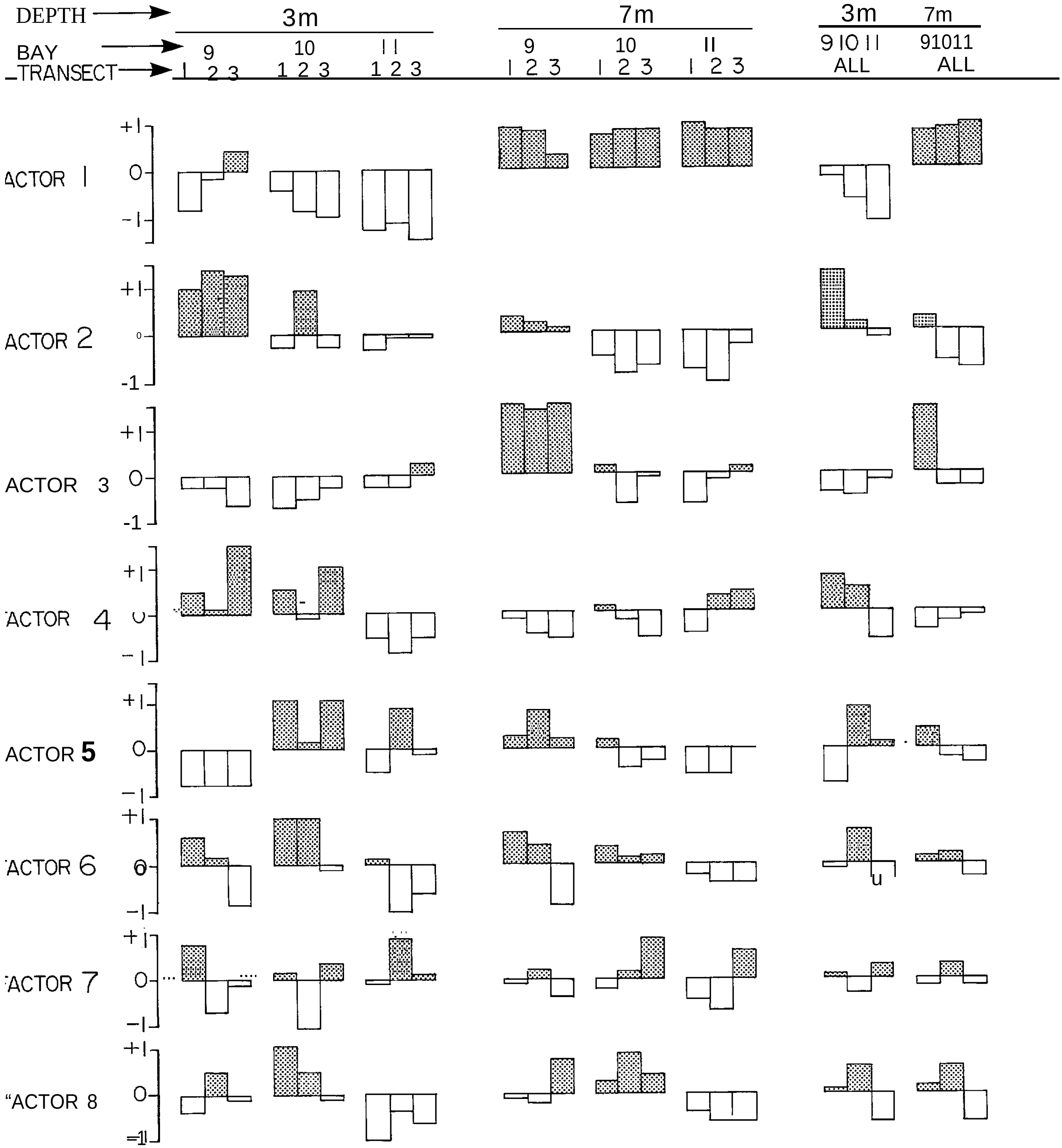

FIG. 6. Mean factor scores for each transect and bay at two depths in Cape
Cape Hatt, northern Baffin Island.

The second factor, which represented primarily the synaptid holothurian Myriotrochus rinkii, two gastropod and three polychaetes, assumed high values only in shallow water on all transects in Bay 9 and on the centre transect in Bay 10.

The three species whose densities were strongly positively correlated with the third factor are all filter feeders. This assemblage was conspicuous only in the deep samples from Bay 9, and this may be indicative of high current velocities in this bay. A strong current generally enhances food supply for filter feeders (Ölscher and Fedra 1977).

Factors 4 and 5 appeared to represent primarily shallow water assemblages, while the remaining three assemblages did not appear to be characteristic of or restricted to any one depth or bay.

Differences in community composition among bays and depths were assessed with a multivariate analysis of variance (MANOVA) using, as dependent variables the factor scores for each of the eight factors derived in the previous analysis. The design was a fixed-effects 2-way factorial MANOVA with bays and depths as the factors and with transects nested within depths and bays. This analysis tests for differences in community composition among bays and depths by simultaneously considering the scores for all eight factors. Since these eight factors, in turn, represent 35 species, the MANOVA tests for overall differences in community composition.

The 2-way MANOVA results (Table 18) show significant among-transect variability, indicating that, overall, the distribution of infaunal

Table 18. One- and two-factor[1] multivariate and univariate analyses of variance for factor scores determined in factor analysis of infaunal density in the study bays at Cape Hatt. Transects are nested within depths and bays; bay, depth and bay-depth interaction effects are tested over the transect MS, and transect effects over the residual MS. F-values are shown with associated significance levels (ns = P>0.01; ** P<0.01, *** P≤0.001) for univariate ANOVAS and actual probabilities for multivariate ANOVAS.

	Two-factor analyses (3 and 7 m depth, n = 144)				One-factor analyses[3]			
					3 m depth (n = 72)		7 m depth (n = 72)	
Source of variation ->	Bay	Depth	Bay x Depth	Transect	Bay	Transect	Bay	Transect
df ->	2,12	1,12	2,12	12,126	2,6	6,63	2,6	6,63
MANOVA[3]								
Pillaistrace	5.32[2]	50.97[2]	3.13	2.73	3.18	2.68	1.10	1.67
df ->	(16,8)	(8,5)	(16,12)	(96,1008)	(10,6)	(30,315)	(10,6)	(30,315)
P ->			0.026	0.000	0.085	0.000	0.475	0.017
ANOVAS								
Factor 1	4.35[2]	112.62[2]	8.54 **	3.09 ***	7.89 ns	4.35 ***	0.85 ns	1.46 ns
Factor 2	21.19 ***	27.77 ***	0.76 ns	1.62 ns	10.55 ns	1.87 ns	12.01 **	1.23 ns
Factor 3	16.72[2]	21.80[2]	19.44 ***	1.32 ns	1.73 ns	1.51 ns	29.30 ***	1.22 ns
Factor 4	16.63[2]	2.93[2]	7.06 **	2.73 **	5.67 ns	2.67 ns	1.56 ns	2.88 ns
Factor 5	2.51[2]	0.26[2]	12.06 **	1.89 ns	7.54 ns	2.36 ns	6.51 ns	1.18 ns
Factor 6	3.56 ns	0.14 ns	0.63 ns	4.06 ***	2.73 ns	4.43 ***	1.03 ns	3.57 **
Factor 7	0.05 ns	0.02 ns	0.86 ns	4.11 ***	0.42 ns	5.06 ***	0.51 ns	3.13 **
Factor 8	14.25 ***	0.22 ns	0.02 ns	1.65 ns	5.74 ns	2.14 ns	9.66 ns	1.16 ns

[1] In the one-factor ANOVA, for each depth, bays were compared. In the two-factor ANOVA, bays and depths were both compared.
[2] Ambiguous because of significance of bay-depth interaction term.
[3] Only factors 1 to 5 were considered in one-factor MANOVA (see text).

assemblages was patchy on the 50 m scale. After accounting for this among-transects variability, it was found that differences between depths within bays were inconsistent among bays (i.e. the bays by depths interaction term was significant). This interaction precluded interpretation of the among-bays or between-depths terms of the 2-way analysis.

Separate MANOVA's were therefore performed on samples from each depth.* These results--like the 2-way MANOVA--showed significant among-transects variability, especially at 3 m depth. However, no significant among-bays differences in community composition were evident at either the 3 m or 7 m depth (Table 18). ANOVA results for individual factors also showed no significant among-bays differences for any of the factors at 3 m, and showed significant among-bays variation for only two of the factors at 7 m.

Figure 7 is a visual portrayal of the relative similarities and differences of the animals present in each bay and at each depth. This 'ordination' of bay-depth combinations (locations) was generated by multiple discriminant analysis (BMDP7M, Dixon and Brown 1977) of the six locations using as variables the eight factors described above. Discriminant analysis derives canonical variables, which are specific linear additive functions of the variables on which the analysis is based (in this case, the eight species assemblages or factors). The particular functions chosen by the analysis are those which 'maximize the separation' of the locations. The analysis was structured such that only two canonical variables were derived, and such that the first of these emphasized factors differing among depths while the second

*In each of these analyses we were able to consider only the first five factors because of the small number of degrees of freedom of the transect term in the test of the bays effect. Inspection of the ANOVA results for individual factors showed that values of the three factors excluded from the 1-way MANOVA did not differ significantly among bays at either the 3 m or the 7 m depth (Table 18).

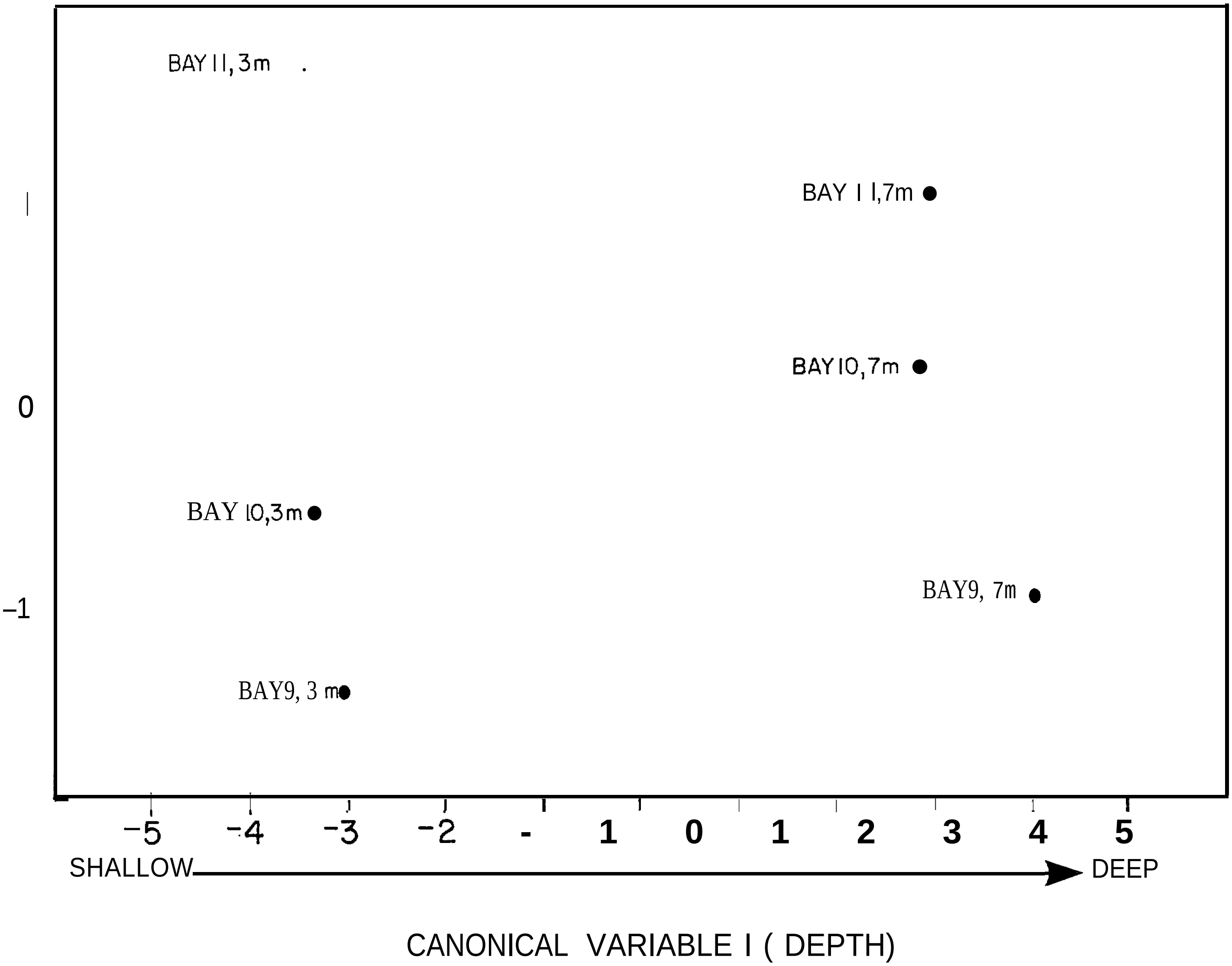

FIG. 7. Similarity of animals found in six depth/bay combinations. The centroid of each combination is plotted against two canonical variables (discriminant functions). The variables were derived by stepwise multiple discriminant analysis of the depth-area combinations, using as predictors the eight factors derived from factor analysis of the 35 dominant infaunal animals. The analysis was structured such that the first canonical variable emphasized depth and the second emphasized location.

emphasized factors differing among bays. Both canonical variables afforded significant ($P<0.005$) discrimination of locations on the basis of the animals present. The visual portrayal represents the mean value of each canonical variable for each location (Fig. 7). This approach, extended to include the time dimension, will be especially useful in comparing pre- and post-spill community composition in the various bays.

Figure 7 shows, on the basis of the types and numbers of animals present, a clear separation of deep and shallow samples, and also shows a consistent pattern of differences among bays. In general, differences between depths appear to be larger than differences among bays within depths. This can be confirmed numerically: The mean Euclidean distance (Walker et al. 1979) between all possible pairs of centroids of similar depths is 1.88 * SD 0.90 (n = 6), while the deep and shallow centroids for particular bays differ by 6.54 ± SD 0.48 (n = 3).

Trophic Relationships

The infaunal animals (excluding gastropod) collected by the airlift sampler were classified into feeding guilds based on data available in the literature (Table 19). The feeding modes follow those described by Fauchald and Jumars (1979).

Filter feeders extract particulate material from the water. Sabellid polychaetes do this externally with a brachial ‘fan’ while bivalves pump water through their body and filter out particulate material with their gills. *Mya truncata* lies buried deep in the sediment and extends a siphon to

Table 19. Feeding mode of benthic infaunal animals (excluding gastropod) fran Cape Hatt, northern Baf fin Island. Species tentatively assigned to feeding modes indicated by ?; numbers in parentheses are number of species in that family or group.

	Polychaetea	Bivalves	Others
Filter feeders	Sabellidae (2+) Owenia fusiformis? Chaeopterids (1)	Mya truncata Thyasiridae Astarte spp. (2) Musculus Spp. (2) Hiatella arctica Serripes groenlandicus	Rhizomolgula globularis
Carnivores	Polynoidae (4) Phyllodocidae (4) Phloe minuta Lumbrineris sp. (1)? Glycera capitata Nephtys ciliata?		
Deposit feeders	Capitella capitata Cistenides spp. (2) Opheliidae (3) Scoloplos armiger Scalibregma Maldanidae (4) Scalibregma inflatum		Myriotrochus rinkii?
Surface deposit feeders	Chaetozone setosa Terebellidae (3) Ampharetidae (2+) Spionidae (5) Trichobranchus glacialis Diplocirrus sp. (1) Aricidea sp. (1)	Macoma calcarea Macoma moesta? Nuculans minuta	Strongylocentrotus droebachiensis

References for feeding hype: Ockelmann 1958; Reid and Reid 1969; Himmelman and Steele 1971; AnSell and Parulekar 1978; Mohlenberg and Riisgård 1978; Fauchald and Jumars 1979.

the surface. Mussels (Musculus sp.) are usually attached to rocks or algae and water enters through a gape in their shell. It should be pointed out that many benthic filter feeders ingest material of benthic rather than pelagic origin (Marshall 1970).

Some deposit feeders burrow through the mud (Capitella capitata) or live in tubes (maldanid polychaetes) and ingest the substate (Fauchald and Jumars 1979). These animals derive their nutrition from bacteria associated with the organic matter and detritus found in the sediments. The deposit feeders listed in Table 19 burrow or live in tubes and generally feed at some depth below the surface of the sediment. The activity of these animals is especially important in reworking the surface layers of the sediment (e.g. Cadée 1979).

Surface deposit feeders feed at the sediment-water interface. Their food includes benthic microalgae and bacteria. Most of the polychaetes included in this group (Table 19) feed by means of tentacles (Fauchald and Jumars 1979). Nuculana minuta extends the palp proboscises over the surface of the sediment (Ansell and Parulekar 1978).

The carnivores are all motile predators.

An animal's mode of feeding may determine its degree of exposure to oil. A short exposure to dispersed oil may not affect filter feeders, which may stop feeding temporarily, but the resultant oil-containing floes that accumulate on the surface of the sediment may seriously affect the surface deposit feeders. In active benthic environments, wave action and sediment transport may incorporate undispersed oil into the sediment and seriously affect burrowing deposit feeders.

Filter feeding was the dominant feeding mode in the three experimental bays at Cape Hatt (Table 20). Biomass of filter feeders was highest in Bay 9, again indicating that current velocities may be higher in this bay than in the others (see also 'Community Structure'), Surface deposit feeding was the second most common mode of feeding at the 7 m depth. Surface deposit feeders were much less abundant at the 3 m depth, perhaps owing to instability of the sediment surface due to wave action. Considering both depths together, carnivores and burrowing and tubiculous deposit feeders showed the least variability among bays.

Epibenthos

For the purposes of the present study, the term 'epibenthos' refers to motile members of the benthic community, including those animals capable of rapid movement through the water column (e.g. crustaceans, fish) and those moving relatively slowly on the sediment surface, but capable of covering relatively large distances due to their size (e.g. urchins, starfish). As previously mentioned, the purpose of this distinction is largely to facilitate the interpretation of any changes in faunal densities in the study bays after oiling. The relative roles of mortality and emigration in determining any changes in the densities of the above animals will not be distinguishable with certainty. Hence relatively little effort is directed to the analysis of their distributions. A further justification for the inclusion of urchins and starfish in this section are the different (and less

Table 20. Mean biomass of animals comprising the four major feeding modes of infaunal animals (excluding gastropods) found at Cape Hatt, northern Baffin Island.

		3 m depth			7 m depth		
		Bay 9	Bay 10	Bay 11	Bay 9	Bay 10	Bay 11
Carnivores	g/m^2	10.56	9.72	7.49	12.48	6.31	4.95
	%	1.82	3.28	9.70	0.45	0.42	0.32
Filter feeders	g/m^2	522.95	256.98	52.52	2579.50	1365.31	1386.23
	%	90.33	86.66	68.04	93.08	91.34	89.99
Deposit feeders	g/m^2	25.79	19.83	14.19	33.46	32.98	33.14
	%	4.45	6.69	18.38	1.21	2.21	2.15
Surface deposit feeders	g/m^2	19.63	9.99	3.00	145.76	90.09	116.18
	%	3.39	3.37	3.89	5.26	6.03	7.54
Total	g/m^2	578.93	296.52	77.20	2771.20	1494.69	1540.50

intensive) sampling methods employed due to the large size and sparse distribution of these animals.

The available data on highly motile epibenthic crustaceans at Cape Hatt are from the same airlift samples upon which infaunal results are based. Estimates for epibenthic crustaceans likely are not as accurate as those for infauna, however, due both to escape of organisms from the area sampled and to inclusion of those inadvertently drawn into the airlift from outside the 0.0625 m^2 sampling area. A modification to the sampler, developed for EAMES studies to overcome this shortcoming (see Thomson and Cross 1980), was not practical in the present study due to difficulties in operating the airlift in the mixed sediment-rock substrate. No quantitative estimates are available for the extent to which epibenthic crustaceans were over- or under-estimated in the present study.

The densities of large surface-dwelling epibenthos (urchins and starfish) were estimated by two methods: counts from 8 to 12 photographs (each covering 0.5 m^2) along each transect, and counts performed _in situ_ within five 1 x 10 m strips beside each transect. No urchins or starfish were present at 3 m; mean density estimates at 7 m for each bay and method, and the total areas on which the estimates are based, are as follows:

	In situ counts			Counts in photographs		
	Urchins (no./m^2)	Starfish (no./m^2)	Area (m^2)	Urchins (no./m^2)	Starfish (no./m^2)	Area (m^2)
Bay 9	4.42	0.10	150	1.46	0.08	13.0
Bay 10	1.56	0.19	150	0.91	0.12	16.5
Bay 11	0.99	0.07	150	0,55	0.00	14.5

Urchin density estimates from photographs were lower than those based on _in situ_ counts on every transect (9 of 9 cases). The observed patchy distribution of urchins along transects may account for this discrepancy. Patches were included in the large areas surveyed, but not in the relatively small area covered by photographs. Differences between techniques in the density estimates for the large starfish _Leptasterias polaris_ did not differ as greatly between techniques (on a per bay basis), and the differences were not in a consistent direction on all transects. All transects contained at least one starfish (based on _in situ_ counts); on 7 of 9 transects no _L. polaris_ were present in photographs, and on the two transects where starfish did occur in photographs the resulting density estimates were higher than those based on _in situ_ counts. This indicates that this starfish was too widely distributed for its density to be accurately estimated by the photographic technique. The photographic method employed in the present study, therefore, appears to be inadequate for estimating the densities of urchins or starfish due to large-scale patchiness and sparse distribution, respectively. Hence only data based on _in situ_ counts are discussed below.

Epibenthic crustaceans collected in airlift samples consisted entirely of ostracods (56.3%), amphipods (34.0%) and cumaceans (9.6%). Ostracods, six species of amphipods, and two species of cumaceans accounted for 86.0% and 82.7% of total numbers and biomass, respectively (Table 21). All of these species are common in nearshore high arctic waters (Sekerak et al. 1976; Buchanan et al. 1977; Thomson and Cross 1980).

Mean densities of major epibenthic taxa and dominant species are shown by transect, bay and depth in Table 22. Densities of ostracods, all

Table 21. Percent contribution to total epibenthic biomass and density by 10 dominant crustaceans in the study bays at Cape Hatt, northern Baffin Island, during September 1980. Based on 144 samples, each covering 0.625 m^2, from 3 and 7 m depths.

Taxon	% of total biomass	% of total density
Ostacoda (Myodocopa)	54.85	27.77
Anonyx nugax (A)	7.42	47.27
Guernea sp. (A)	6.99	0.71
Lamprops fuscata (C)	6.65	0.87
Paroediceros lynceus (A)	2.49	3,06
Monoculodes borealis (A)	2.04	0.92
Pontoporeia femorata (A)	1.50	1.55
Ostracoda (Podocopa)	1.44	0.11
Brachydiastylis resima (C)	1.31	0.29
Stenothoidae sp. a (A)	1.29	0.17
Total	85.99	82.71
Total epibenthos	1152.1 ind./m^2	7.17 g/m^2

(A) = amphipod (C) cumacean.

Table 22. Mean density (no. $/m^2$) of major epibenthic taxa and dominant species of epibenthic animals on transects at two depths in three bays at Cape Hatt, northern Baffin Island, during September 1980. Data are expressed as mean ± standard deviation and are based on 8 replicate 0.0625 m^2 airlift samples at each depth and transect.

		3 m Depth			7 m Depth		
Taxa	Transect	Bay 9	Bay 10	Bay 11	Bay 9	Bay 10	Bay 11
Ostacoda	1	40.0 ± 46.8	34.0 ± 77.2	10.0 ± 14.7	714,0 ± 293.4	1264.0 ± 679.6	1458.0 ± 549.6
	2	58.0 ± 58.6	72.0 f 159.8	8.0 ± 12.1	564,0 ± 427,5	1902.0 ± 691.1	938.0 ± 383.2
	3	30.0 ± 30.2	28.0 ± 33,9	10,0 ± 17.0	1620.0 ± 872.1	2020.0 * 1024.3	944.0 ± 1033.3
	All	42.7 ± 46.1	44.7 ± 101.6	9.3 *14.1	966.0 ± 735.5	1728.7 * 848.7	1113.3 ± 723.6
Amphipoda	1	188.0 ± 81.0	332.0 ± 244. 0	432.0 ± 215,0	394. 0 ± 368.7	746.0 ± 484.9	614.0 ± 376,6
	2	322,0 ± 194.7	436.0 * 235.1	226.0 * 96.2	178.0 * 81,8	552.0 ± 262.0	542.0 ± 273,2
	3	158.0 ± 62.5	264.0 * 324.3	200.0 ± 122,2	236,0 * 159.7	628.0 * 341.2	594.0 * 264.5
	All	222,7 ± 141.5	344.0 ± 268.6	286. 0 ± 180.7	269.3 i 244.7	642.0 ± 366.8	583.3 ± 296.9
Anonyx nugax	1	2.0 ± 5.7	10.0 ± 17.0	64.0 ± 142.9	192.0 ± 372,2	442.0 ± 464.8	124,0 ± 102.2
	2	6.0 ± 11.9	26.0 ± 67.3	2.0 ± 5.7	34.0 ± 42.3	184.0 ± 64.6	46.0 ± 45.6
	3	4.0 ± 7.4	2.0 ± 5.7	6.0 ± 11.9	32,0 ± 37,3	262.0 ± 231,1	100.0 ± 74.4
	All	4.0 ± 8.5	12.7 ± 39.7	24.0 ± 84.2	86,0 ± 221,3	296.0 ± 309,0	90.0 ± 81.3
Guernea sp	1	52.0 ± 29.3	64. 0 ± 95,2	18.0 ± 21.7	108,0 ± 41.7	100.0 ± 68.2	192.0 ± 89.7
	2	112.0 ± 80.2	46.0 ± 47.9	20.0 * 38.0	58,0 ± 41.8	130.0 ± 70.7	132.0 ± 81,0
	3	52.0 ± 57.8	14.0 ± 18.0	4.0 ± 7,4	108.0 ± 91.2	102.0 ± 101.1	132.0 ± 116.6
	All	72.0 ± 63.8	41.3 ± 63.3	14.0 ± 25.5	91.3 * 64.6	112.7 * 78.9	152. 0 ± 97,0
Paroediceros lynceus	1	6,0 ± 8.2	18.0 ± 44.8	22.0 i 14.7	0.0 * 0.0	40.0 ± 25,7	52,0 ± 74.4
	2	8.0 ± 17.1	76.0 * 108.8	8.0 ± 12.1	14.0 ± 13,4	44.0 ± 63.9	62.0 ± 90.3
	3	0,0 ± 0.0	8.0 ± 17.1	4.0 ± 7.4	0.0 ± 0.0	40.0 ± 50.6	114.0 ± 108,0
	All	4.7 ± 11.0	34.0 ± 72.4	11.3 ± 13.7	4.7 i 10.0	41.3 ± 4?.2	76. 0 ± 92.1
Cumacea	1	30,0 ± 46.4	48.0 ± 105.8	30.0 * 43.1	152.0 ± 48.4	190.0 * 93,1	328.0 ± 184.8
	2	42.0 ± 38.2	60.0 ± 100.4	2.0 * 5.7	144.0 * 143.4	126.0 ± 104,5	286,0 ± 155,2
	3	8.0 ± 8.6	2,0 * 5,7	0.0 ± 0.0	130.0 ± 128.7	92.0 ± 65.6	312.0 * 166.3
	All	26.7 ± 36.4	36.7 *84.5	10.7 ± 27,8	142.0 ± 110.0	136.0 ± 94. B	308.6 ± 162.7
Lamprops fuscata	1	26.0 ± 44,4	48.0 ± 105.8	30,0 ± 43.1	112.0 ± 51.3	162.0 ± 83.5	146.0 ± 135.1
	2	40.0 ± 40.1	18.0 ± 18,0	2,0 ± 5.7	114.0 ± 131.8	92.0 ± 92.4	166.0 ± 140.0
	3	6.0 ± 8.3	2.0 ± 5.7	0.0 ± 0.0	100.0 ± 108.1	76.0 ± 53.9	240.0 t 136.6
	All	24.0 ± 36.2	22.7 ± 62.4	10.7 ± 27.8	108.7 ± 98.4	110.0 ± 84. 0	184.0 ± 137.5

cumaceans and the cumacean Lamprops fuscata were considerably higher at the 7 m depth than at 3 m. Amphipods were more evenly distributed at the two depths, although a tendency toward higher numbers at the 7 m depth was evident, both for total amphipods and for the individual species included in Table 22. Differences among bays were also apparent for all taxa considered. For reasons outlined above, no statistical treatment of the distribution of epibenthic crustaceans is presented.

The densities of the urchin Strongylocentrotus droebachiensis and the starfish Leptasterias polaris at 7 m depth in the study bays are shown in Table 23. No urchins or starfish were present on transects at the 3 m depth. At a depth of 7 m L. polaris occurred at a relatively low and even density in the three bays. Strongylocentrotus droebachiensis was most abundant in Bay 9 and least abundant in Bay 11 (Table 23). Based on one-factor nested ANOVA of urchin density, variation among transects within bays was non-significant ($F = 0.833$, $df = 6,36$; $p = 0.552$), whereas variation among bays was highly significant ($F = 63.271$, $df = 2,6$; $P < 0.001$).

Strongylocentrotus droebachiensis is widely distributed and often relatively abundant (up to 14 individuals/m^2) in the Lancaster Sound area, whereas the distribution of Leptasterias polaris is more restricted (Thomson and Cross 1980). Both species are of interest due to their trophic positions. Strongylocentrotus droebachiensis is a herbivore whose impact on benthic algal populations has been found to be considerable on both the east and west coasts of Canada (Miller and Mann 1973; Foreman 1977). L. polaris is a top predator feeding primarily on large bivalves, and hence may be indirectly affected by oil through changes in bivalve populations. Thus ,

Table 23. Density (no/m*) of urchins and starfish in the study bays at Cape Hatt, northern Baffin Island, during September 1980. Based on *in situ* counts within five 1 x 10 m areas along each of three transects in each of three bays at a depth of 7 m.

Species	Transect	7 m Depth		
		Bay 9	Bay 10	Bay 11
Strongylocentrotus droebachiens is	1	3.26 ± 1.47	1.66 ± 0.66	0.9210.31
	2	5.04 ± 1.10	1.62 ± 0.86	1.00 ± 0.42
	3	4.96 ± 1.33	1.4010.64	1.06 ± 0.59
	All	4.42 ± 1.48	1.56 ± 0.69	0.99 ± 0.42
Leptasterias polaris	1	0.04 ± 0.09	0.24 ± 0.15	0.08 ± 0.08
	2	0.14 ± 0.11	0.12 ± 0.08	0.08 ± 0.18
	3	0.12 ± 0.11	0.22 ± 0.13	0.06 ± 0.05
	All	0.1010.11	0.19 ± 0.13	0.07 ± 0.11

in spite of the above-mentioned interpretational difficulties caused by the mobility of these animals, the densities of urchins and starfish should be carefully monitored throughout the course of this study. Observations on behaviour and mortality in these species may also provide information on oil effects.

Fish were not a conspicuous feature of the marine fauna in the study bays at Cape Hatt. Pelagic fish were not observed, and benthic fish were rarely encountered. A total of 10 fish belonging to four species were collected in airlift samples (Table 24). Gymnocanthus tricuspis and juvenile Gymnocanthus sp. were most common, and only one individual was collected of each of Gymnelis viridis, Eumicrothemus derjugini and Icelus sp. Most of the fish collected were from the 3 m transects in bays 9 and 11; the absence of fish on 3 m transects in Bay 10, however, may be of little significance considering the small total number collected. All of the species collected are previously known from arctic Canada (Leim and Scott 1966).

Table 24. Species of fish collected in airlift samples in the three study bays at Cape Hatt, northern Baffin Island, during September 1980.

Depth	Bay	Transect	Species	Biomass (g)	Total Length (mm)
2 m	9	1	Gymnocanthus tricuspis	5.45	82
		2	Gymnocanthus tricuspis	4.14	76
		3	Gymnelis viridis	0.55	61
	11	1	Gymnocanthus sp. (juvenile)	0.02	22
		2	Gymnocanthus tricuspis	23.85	119
			Gymnocanthus sp. (juvenile)	0.28	35
		3	Gymnocantus sp. (juvenile)	0.03	17
			Gymnocantus sp. (juvenile)	0.02	19
7m	10	2	Eumicrothemus derjugini (juvenile)	0.01	11
	11	1	Icelus sp. (juvenile)	0.14	22

Macrophytic Algae

The benthic marine algae of the North American Arctic have been studied intermittently since the early nineteenth century, but early reports consisted of little more than species lists (Kent 1972). Recently, floristic and ecological studies have been performed in Labrador and Ungava Bay (Wilce 1959), West Greenland (Wilce 1964), Prince Patrick Island (Lee 1966), Pangnirtung Fiord (Kent 1972), and in several areas in the northern and southwestern Canadian Arctic (Lee 1980). These studies have shown that macrophytic algae are a common feature of arctic and subarctic nearshore waters , both on exposed rocky coasts and on soft bottoms. In the latter case they are either loose-lying and still viable or are attached to mud, small rocks, shells and polychaete tubes (Lee 1966; Lee 1973, 1980). These floristic studies have provided much valuable information on species composition, zonation and reproduction of littoral and sublittoral macrophytes in high latitudes. Quantitative studies of kelps and conspicuous understory algae have also been carried out at several locations in the Lancaster Sound area (Thomson and Cross 1980), but to date combined floristic/biomass studies of benthic macroalgae have not been reported for the Canadian Arctic.

The overall effects of oil on macroalgal communities have not been studied in the Arctic, but Hsiao et al. (1978) determined that in situ primary production in two macroalgal species in the Beaufort Sea was significantly inhibited by all types and concentrations of oil tested. In other latitudes studies of the effects of oil spills with and without the use of chemical dispersants have often demonstrated changes in the abundance of littoral and sublittoral macrophytic algae (see Natural Academy of Sciences 1975, Table 4-l). In some cases widespread mortality has been observed (e.g. Bellamy et al. 1967; Thomas 1973), whereas in other cases no mortality was apparent immediately following the spill (e.g. Nelson-Smith 1968). Subsequent changes following spills have included a proliferation of macroalgal growth, which has been attributed to the oil-related absence of herbivores including sea urchins (North et al. 1965) and limpets (Nelson-Smith 1968).

Species Composition

A total of 29 species of macroalgae were collected in the study bays at Cape Hatt (Table 25). This is a relatively small number when compared with the 126 species known in the arctic sublittoral (Wilce 1973) or the 183 species and varieties (littoral and sublittoral) recorded by Lee (1980). This difference undoubtedly is largely attributable to the small area studied at Cape Hatt relative to the wide coverage in the above investigations. To a smaller extent, the difference probably also reflects the focus of the present Study on dominant species and the lack of particular effort to collect small or rare (and hence easily overlooked) species. Species determinations were based on (1) herbarium specimens collected by hand on each transect, plus (2) single airlift samples from each of Bays 10 and 11 (2 m depth), which were quickly scanned for species present. Two of the 29 species collected in the study area were found only in these airlift samples (Table 25).

Table 25. Species list and distribution of macrophytic algae collected in three bays at Cape Hatt, northern Baffin Island, during August and September 1980. Depth distribution is shown for species present in systematic hand collections along transects at 3 m and 7 m depths.

Species and Authority	Bay 9			Bay 10			Bay 11		
	3m		7m	3m		7m	3m		7m
Chlorophyceae									
Ulothrix flacca (Dilwyn) Thuret in LeJolis								A	
Chlorochytrium schmitzii Rosenvinge	P			P			P		
Spongomorpha sonderi Kuetzing			P		*			A	P
Chaetomorpha linum (O. F. Mueller) Kuetzing				P		P	P	A	P
Chaetomorpha melagonium (Weber et Mohr.) Kuetzing				P			P	A	
Phaeophyceae									
Pilayella littorals (L.) Kjellman	P		P	P	A	P	P	A	P
Symphyocarpus strangulans Rosenvinge					A				
Phaeostroma pustulosum Kuckuck						P			
Elachistea lubrica Ruprecht							P		
Stictyosiphon tortilis (Ruprecht) Reinke	P		P	P	A	P	P	A	P
Platysiphon verticillatus Wilce	P		P			P			P
Dictyosiphon foeniculaceus (Hudson) Greville	P		P	P	A	P		A	P
Desmarestia aculeata (L.) Lamouroux		*			*				P
Desmarestia viridis (O. F. Mueller) Lamouroux	P			P		P			
Chorda filum Linnaeus	P				A		P		
Chorda tomentosa Lyngbye	P			P	A	P	P		P
Agarum cribrosum (Mertens) Bory		*				P			P
Laminaria saccharin (L.) Lamouroux				P			P		
Laminaria solidungula J. Agardh		*		P					
Laminaria sp.			P			P			P
Haplospora globosa Kjellman		*							
Sphacelaria plumosa Lyngbye	P			P	A				
Sphacelaria arctica Harvey		*		P	A	P		A	
Fucus distichus L. subsp. distichus	P		P	P	A		P		
Rhodophyceae									
Ahnfeltia plicata (Hudson) Fries		*							
Neodilsea integra (Kjellman) A. Zinova	P			P	A				
Halosaccion ramentaceum (L.) J. Agardh									
Palmaria palmata (L.) O. Kuntze				P					
Polysiphonia arctica J. Agardh		*			*				
Rhodomela confervoides (Hudson) Silva f, flagellaris Kjellman		*						A	

P = Present in systematic hand collections.
* = Present only in off-transect collections, 2-12 m depths.
A = Present in airlift collections at 3 m depth (see text).

The distributions of algal species collected by hand and by airlift are shown for each bay and depth in Table 25. Comparison of the two types of data for locations with both hand and airlift samples further points out the inadequacy of the hand collection technique for small or rare species; in addition to the two species found only in airlifts, airlifts provided five new 'location records' for species that were present in hand collections from other depths and bays. Hence, floristic comparisons among transects, depths and bays must await more detailed analyses of algae from 1980 airlift samples, to be carried out in 1981.

A brief description of the 3 m algal community is warranted, however, based on in situ observations, and on the general appearance of algae from airlift samples. The bulk of the algae in most samples was a tangled mat of filamentous and fine dendritic forms; Pilayella littorals, Dictyosiphon foeniculaceous and Stictyosiphon tortilis were apparently the dominant species in each of three samples (one from each bay) that were examined microscopically. Likely because of their abundance, these species were also present in hand collections from all or most bays and depths (Table 25). Extending above this tangled mat, and conspicuous both due to size and abundance, were long, unbranched Chorda spp. and short foliose species including Fucus distichus, Neodilsea integra, Palmaria palmata and small Laminaria Spp. These 'canopy' species were apparently more unevenly distributed than was the lower algal stratum, both within and among bays.

Biomass

Mean biomasses of algae collected in airlift samples along transects at 3 m and 7 m depths in each of the study bays are shown in Table 26. Overall

Table 26. Mean biomass of macrophytic algae at 3 m and 7 m depths in three bays at Cape Hatt, northern Baffin Island, during September 1980. Biomass expressed as 10% formalin-preserved wet weight (g/m^2); n = 8 airlift samples per transect; each sample covered 0.0625 m^2.

		Bay 9	Bay 10	Bay 11
Depth	Transect	mean ± SD	mean ± SD	mean ± SD
3 m	1	611 ± 298	1351 ± 812	320 ± 337
	2	295 ± 134	689 ± 528	566 ± 421
	3	514 ± 159	1294 ± 835	1005 ± 826
	All	473 ± 241	1112 ± 769	631 ± 616
7 m	1	369 ± 159	554 ± 491	206 ± 220
	2	179 ± 89	442 ± 226	138 ± 65
	3	175 ± 44	334 ± 166	310 ± 306
	All	241 ± 139	444 ± 235	218 ± 223

average biomass of macroalgae was 739 and 301 g/m^2 at 3 and 7 m depths, respectively. The maximum transect mean was 1351 g/m2 and the maximum single-sample estimate was 3020 g/m^2. These values (based on formalin-preserved wet weight) probably underestimate fresh weight; Thomson and Cross (1980) reported a considerable (>30%) formalin-induced reduction in the weight of understory algae from Cape Fanshawe, Bylot Island. Algal biomass at Cape Hatt (Table 26) was higher than the biomass of macroalgae other than kelp at most of the 5 and 10 m stations studied by Thomson and Cross (1980). However, kelp biomass in the Lancaster Sound area was considerably higher (0.5-12.7 kg/m^2 fresh wet weight). No estimates of kelp biomass were made at Cape Hatt, either on transects or in the narrow *Laminaria* zone at 4-5 m depth.

Algal biomass varied considerably among replicate samples within transects (Table 26). Two-factor, nested ANOVA on log-transformed data showed significant ($P<0.005$) variation both among transects and between depths. Variation among bays was not significant ($P>0.01$), however, when compared with variation among transects within depths and bays. No interaction between the depth and bay factors was evident:

Source	df	MS	F	P
bays	2,12	1.7018	6.67	0.0113
depths	1,12	4.4865	17.59	0.0012
Bay x depth	2,12	0.0324	0.13	0.8819
transects within bays and depths	12,126	0.2551	3.13	0.0006
Error	126	0.0814		

Substrate Cover

Mean percent of the substrate covered by macrophytic algae on each transect and in each bay, based on *in situ* estimates within 10 m^2 areas, are shown in Table 27. Separate estimates were made for larger foliose algae (*Fucus distichus, Neodilsea integra* and *Palmaria palmata*), and for the Lower stratum of mixed filamentous and dendritic forms. Because both types occurred together in some areas, the sum of the two estimates does not necessarily equal total bottom cover. Percent cover by the mixed lower stratum was usually relatively high (68 to 90%) on 3 m transects and relatively low (2 to 12%) on 7 m transects. Intermediate values (19 to 33%) were estimated for some transects at both depths, however (Table 27). Larger foliose algae provided little bottom cover at the 3 m depth in Bay 9, but contributed substantially (10 to 35%) to bottom cover on the shallow transects in the other two bays. On the 7 m transects, smaller foliose algae were replaced by large and generally solitary individuals of *Laminaria* spp. and *Agarum cribrosum*. Kelp was present at 7 m depth in Bay 9 (counts were not made), and was widely distributed in Bays 10 and 11, averaging a little more than one plant per 10 m2 (Table 27).

No correlation between estimated percent cover of 'understory' algae and biomass, on a transect by transect basis, was evident at either depth ($r = -0.20$ and -0,02 for 3 m and 7 m, respectively). This is likely due both to variation among transects in the thickness of the algal mat and to variation among bays in species composition, particularly with respect to the larger foliose algae. For example, at the 3 m depth the highest cover estimate and the lowest biomass estimate are both from Bay 9 (Tables 26 and

Table 27. Estimates of macrophytic algal density based on *in situ* counts at 3 m and 7 m depths in the study bays at Cape Hatt, northern Baffin Island, during September 1980. Data are expressed as mean ± SD; n = five 1 x 10 m areas on each transect.

		3 m Depth		7 m Depth	
Bay	Transect	Understory[1] (%)	Canopy[2] (%)	Understory[1] (%)	Kelp[3] (no./10 m^2)
9	1	68 ± 13	2 ± 3	10 ± 5	-
	2	87 ± 10	<1	3 ± 2	-
	3	90 ± 5	<1	2 ± 2	-
	All	82 ± 14	1 ± 2	5 ± 5	-
10	1	72 ± 8	11 ± 2	11 ± 4	1.6 ± 0.9
	2	33 ± 6	13 ± 5	7 ± 5	1.2 ± 1.1
	3	19 ± 10	35 ± 25	6 ± 4	1.4 ± 1.1
	All	41 ± 24	20 ± 18	8 ± 5	1.4 ± 1.0
11	1	28 ± 17	10 ± 7	19 ± 18	2.0 ± 1.0
	2	70 ± 34	18 ± 18	12 ± 16	1.2 ± 1.1
	3	79 ± 24	22 ± 11	26 ± 31	0.4 ± 0.9
	All	59 ± 33	17 ± 13	19 ± 22	1.2 ± 1.1

1 Primarily *Dictyosiphon foeniculaceus*, *Stictyosiphon tortilis* and *Pilayella Littorals* (see text).
2 Includes *Fucus distichus*, *Neodilsea integra* and *Palmaria palmata*.
3 Includes *Laminaria* sp. and *Agarum cribrosum*.
- Data not collected.

27) where foliose algae were scarce. This relationship should be examined further when biomass data for dominant species become available.

The present report is the first to present quantitative results concerning arctic macrophytic algae occurring on the mixed sediment-rock bottom type such as that found at Cape Hatt. The qualitative appearance of algal communities in transect photographs, the percent cover estimates from in situ counts, and the data on biomass and species composition from airlift samples constitute pre-spill information on a variety of variables. These data will be used to detect and assess any post-spill changes in the macrophytic algae of the study bays.

SUMMARY

On the basis of preliminary surveys at Cape Hatt, northern Baffin Island, during August 1980, three bays, two depths and three contiguous 50 m transects at each depth in each bay were selected using as selection criteria (1) similarity of substrate, flora and fauna, and (2) facility of sampling. During September 1980 the first pre-spill suite of systematic sampling was carried out on each transect. The work on each transect included (1) collection of eight samples, each covering 0.0625 m2, using a diver-operated airlift sampler, (2) collection of 8-12 photographs, each covering 0.5 m^2, and (3) in situ counts of large organisms within five areas, each 1 x 10 m in dimensions. All fauna $\geq$1 mm in length were sorted from airlift samples, identified to species where possible, counted and weighed. All bivalves and holothurians were measured, and wet and dry weights were obtained for a subsample of three dominant bivalve species from each bay, Photographs and

in situ counts were used to provide a permanent visual record of the study area and to enumerate large and widely distributed organisms.

Summary--Infauna

The shallow water infaunal benthic community found at Cape Hatt was typical of that found in nearshore regions of Eclipse Sound, Lancaster Sound and channels to the west. Benthic biomass estimates from the present study were higher than those recorded in most other arctic areas, probably because our sampler penetrated farther into the sediment and provided a more complete collection of the animals present. Grabs and other samplers used in previous studies probably did not penetrate to a sufficient depth to collect all of the large, deeply burrowing individuals of *Mya truncata*. This and other bivalve species accounted for most of the biomass of infauna collected at Cape Hatt, and polychaetes and bivalves in approximately equal proportions accounted for most of the numbers.

We compared the infauna in the various sampling areas (3 bays, 2 depths, 3 transects per bay and depth) using analysis of variance (ANOVA). The density and biomass of bivalves, polychaetes and total infauna, and the density of seven selected infaunal species (13 variables altogether), were examined using a fixed-effects, two-factor (bays and depths) ANOVA design in which transects were nested within bays and depths. For many variables, bay x depth interaction effects were significant, indicating that the patterns of among-bay variation at 3 m and 7 m depths were not consistent between depths. This confounded the interpretation of main effects (variation among bays and between depths) and necessitated analysis by separate one-factor (bays) ANOVAs for data from each depth. The latter analyses showed that six of the 13 variables differed significantly ($P<0.01$) among bays at the 3 m depth, but only one did so at the 7 m depth. Variation between depths was highly significant for seven of the eight variables whose bay x depth interactions were not significant. The comparative similarity of the pre-spill infauna at 7 m depth in the three bays will facilitate the analysis of oil spill effects.

Factor analysis of the densities of the 35 most common species (89.3% of total infauna) identified eight 'assemblages' of animal species that tended to occur together. The first of these assemblages bore a very close resemblance to the ubiquitous arctic Macoma community. We used one- and two-factor nested (see above) multivariate analyses of variance (MANOVA), with the eight sets of factor scores as dependent variables, to compare the infaunal communities in relation to bays, depths and transects. The two-factor MANOVA showed a significant bay by depth interaction. One-factor MANOVA showed no significance among-bay difference in community composition at either the 3 m or the 7m depth.

Mean lengths of two bivalve species (Mya truncata and Astarte borealis) and the mean oral ring diameter of the holothurian Myriotrochus rinkii were significantly larger at 7 m depth than at 3 m. Of the five species tested, only Mya truncata showed significant among-bay differences in length. The length-weight relationships of the three bivalve species that were studied were best expressed by power curves ($y = ax^b$). Analysis of covariance showed that the exponent in this relationship differed significantly among bays for Mya truncata and Astarte borealis. For Macoma calcarea, neither the exponent nor the dry meat weight after adjusting for length differed among bays.

In fauna were classified into feeding guilds based on data available in the literature. In the study bays at Cape Hatt, filter feeding was the dominant feeding mode, and surface deposit feeding the second most common mode. Carnivores and burrowing and tubiculous deposit feeders showed the least among-bays variability in biomass.

Summary--Epibenthos

For the purposes of the present study, the 'epibenthos' was defined as those animals capable of motion. For these animals, any temporal changes in density might be a result of either mortality or emigration, or both, and the contributions of these two sources of variation would not be readily distinguishable. This group was, therefore, treated in less detail than the relatively immobile infauna.

Epibenthic crustaceans collected in airlift samples consisted of ostracods, amphipods and cumaceans. Relatively few species, all of which are common in nearshore high arctic waters, comprised the majority of the numbers and biomass collected. Ostracods, cumaceans and, to a lesser extent, amphipods were more abundant at the 7 m depth than at 3 m, and among-bay differences in densities were also apparent.

A total of 10 fish belonging to four species were collected in airlift samples. Most were *Gymnocanthus tricuspis* and juvenile *Gymnocanthus* sp. collected on the 3 m transects.

Density estimates of the urchin *Strongylocentrotus droebachiensis* and the starfish *Leptasterias polaris* were more accurate when based on *in situ* counts than when based on counts from photographs. This was attributable to the patchy (urchins) and sparse (starfish) distributions of these animals and the relatively small area covered by photographs. No urchins or starfish were observed on the 3 m transects; at 7 m, densities of _L. polaris_ were low and relatively even in the three bays, whereas _S. droebachiensis_ was more abundant and significantly variable among bays.

Summary--Macroalgae

The macrophytic algal community in the study bays at Cape Hatt was dominated by a basal stratum of filamentous and dendritic forms consisting primarily of _Pilayella littoralis, Stictyosiphon tortilis_ and _Dictyosiphon foeniculaceus_. A 'canopy' of foliose algae including _Fucus distichus_, _Neodilsea integra_ and _Laminaria_ spp. was unevenly distributed at the 3 m depth both within and among bays. At 7 m, sparsely distributed kelps (_Laminaria_ spp. and _Agarum cribrosum_) were the only conspicuous canopy macroalgae.

Based on two-factor nested ANOVA (see above), the biomass of macroalgae varied significantly ($P \leq 0.01$) among transects within bays and depths, and was significantly higher at the 3 m depth than at 7 m. Variation among bays, however, was not significant when compared with variation among transects within bays and depths. Percent bottom cover (based on _in situ_ estimates) by the lower algal stratum was usually high at 3 m at low at 7 m, but intermediate values were estimated for some transects at both depths. No correlation was evident between these estimates and biomass estimates on a transect by transect basis, likely due to variation in thickness of the lower stratum and in the distribution of foliose 'canopy' species.

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APPENDIX 1. hates and locations (depth, bay, transect, and number of metres from N to S along the transect line) of each airlift sample collected at Cape Hatt in 1980.

Depth	Bay	Transect	Replicate 1	2	3	4	5	6	7	8	Date(s)
7m	9	1	2	8*	2@-	23*	31	35	36	43	1 Sept
		2	6	24*	25	32*	37	43	43*	48	31 Aug, 1 Sept
		3	2	8*	20*	23*	31	35*	36*	43	31 Aug
	10	1	1	2*	7*	13*	14	16	29*	31	3 Sept
		2	5*	8	11	16*	20*	24	33*	41*	3 Sept
		3	5	9*	16*	20	24*	25	38*	44	3 Sept
	11	1	1	5*	12*	23*	24	33	39*	40*	4, 5 Sept
		2	6	12*	14*	16*	2P-	29	40*	41	5, 6 Sept
		3	4*	20	25*	27	28	40	43*	45*	6 Sept
3m	9	1	2*	5	10	11*	14	20	33	39*	10 Sept
		2	1*	9	10	17	24*	30	36	44	10 Sept
		3	6*	16*	21	27	30*	33	38	45	10 Sept
	10	1	4*	11	30	3%	37*	43	45	46*	7 Sept
		2	3*	6*	11	13	17*	32*	44	46	7 Sept
		3	2*	5*	8	13*	14	30	31	37*	8 Sept
	11	1	0*	6*	12	16*	21	41	44	45*	9 Sept
		2	1*	12*	19*	26	27	30	39*	47	9 Sept
		3	0	1*	6	7	14*	16*	18	42*	9 Sept

* Indicates sample taken seaward of transect line.